Original Research Article

The biological activity of *Cupressus sempervirens* extracts against *Musca domestica*.

Abstract:
The biological activity against the larval, pupal and adult stages, moreover, the efficacy on reproductive potential, antifeedant and repellency activity of ethanolic, acetone and petroleum ether, leaves and stems extracts of *C. sempervirens* against the housefly, *M. domestica* were evaluated. The larval and pupal duration, pupal mortality, adult emergence and growth index were highly affected by different extracts tested. The antifeedant and repellent activity of was varied depending on the solvent, plant parts used in extraction and the dose of extract. Tested extracts significantly reduced the fecundity and increased the sterility. Based on LC_{50}, the toxicity may be arranged as follows: leaves > stems. Petroleum ether extract from leaves was more effective in inducing the fecundity, antifeedant, repellent actions and egg-hatchability than those from stems. These results may provide an opportunity to develop alternatives to costly organic pesticides using some available cheap plants, which are usually safe to the environment and to other living organisms.

Keywords: *C. sempervirens, M. domestica,* toxicity, fecundity, antifeedant, pesticides.

Introduction

The housefly, *M. domestica* (Diptera: Muscidae) is cosmopolitan, it generally breeds in decaying organic matter and feeds in manure, garbage and food left out by humans (Morey and Khandagle, 2012). The housefly is an important medical insect pest that causes irritation, spoils food and acts as a vector for more than 100 human and animal pathogenic organisms such as entomopathogenic bacteria, enterovirus and protozoa cysts (Hanan, 2013). Adult houseflies have been shown to transmit pathogens from their sponging mouthparts, through vomitus on the sticky parts of the feet and through the intestinal tract, thereby contaminating food and propagating disease (De Jesús *et al*., 2004).

Control of housefly largely relies on chemical insecticides. Unfortunately, houseflies have developed resistance to most of the synthetic insecticides (Khan *et al*., 2013). In addition, synthetic insecticides have an adverse effect on the environment, health and threat of persistence the bio-magnifications through the food chain (Kumar *et al*., 2012; Ito *et al*., 2015). Recently, the application of botanical 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 synthetic counterparts (Singh *et al*., 1996). Therefore, alternatives to conventional insecticides are required to be developed from the active ingredients of plant origin, and these compounds may serve as insecticides, antifeedants, repellents as well as attractants (Murugesan *et al*., 2016; Ito and Ighere, 2017). *Cupressus sempervirens* is a medicinal plant has antiseptic, aromatherapeutic, astringent, balsamic or anti-inflammatory, antispasmodic, astringent, antiseptic, deodorant and diuretic activities. Several monoterpenes, diterpenes, polyphenols, flavonoids, flavonoid glycoside and bioflavonoids have been isolated from this plant (Khan *et al*., 2017).

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In the present study, we aimed at evaluating the biological, antifeedant and repellent activities of *C. sempervirens* extracts against the larvae and adults of the housefly, *M. domestica*.

Materials and Methods

1. Laboratory maintenance of *M. domestica*.

The culture of the housefly was maintained for several generations under controlled conditions of 27±2°C and 70-75 RH and 12-12 light/dark. The emerged flies were fed on dry diet (milk powder) and sucrose solution. Eggs were collected from paper strips or from cotton pads of feeding. Larvae were reared on an artificial diet (wheat bran, milk, powder yeast; 200:100:5gm) per 200ml of distilled water according a method described by (Busvine, 1962).

2. Extraction of plant materials.

Cupressus sempervirens was collected from Sadat City, Cairo-Alexandria desert road, El-monofiya Governorate and left to dry away from sun rays at room temperature (27±2ºC) for 5 to 10days. Then, *C. sempervirens* leaves and stems pulverized to powder separately in a hammer mill. One hundred grams of powder from *C. sempervirens* (leaves and stems) for each solvent separately were extracted using 300ml of 70% ethanol, acetone and petroleum ether solvents at room temperature. After 24 h., the supernatants were decanted, filtrated through Whatman filter paper (No. 5) and dried in a rotary evaporator at 40ºC for (2-3hours) for ethanol and (40-60minutes) for the other solvents. The dry extracts were weighed and kept at -4ºC till using for experiments.

3. Experimental bioassay.

In order to study the toxicity of the concerned plant extracts, the tested material of the 70% ethanol extracts was dissolved in 0.1ml of ethanol, while the tested material of acetone and petroleum ether extracts was dissolved in 2drop of Tween$_{80}$ as emulsifier to facilitate the dissolving oils of tested material in 250ml water. Larval artificial diet was mixed with different concentrations of each concerned extract to detect mortality percent. Then, twenty five of third 3rd instar larvae were put immediately into plastic cups contained media mixed with different concentrations of extracts. Three replicates were usually used for each tested concentration. All plastic cups were incubated under controlled conditions of temperature 27±2°C, 70-75% RH and 12-12 light-dark regime. Control larvae received 0.1 ml of ethanol or 2 drop of Tween$_{80}$ in 250ml water. Mortality was recorded daily and dead larvae and pupae were removed daily.

Larval mortality percent was estimated using the following equation (Briggs 1960): larval mortality % = A – B / A × 100 (where: A = number of tested larvae, B = number of tested pupa). The pupation rate was estimated by using the following equation: pupation % = A/B×100.*Where:* A = number of pupae, B = number of tested larvae. The pupal mortality percentage was estimated by using the following equation: pupal mortality % =A–B/A× 100.*Where:* A = number of produced pupae, B = number of observed adults. Pupal duration was calculated as interval between the commencement of pupation and the commencement of adult emergence. The emerged adult males and females were counted and the adult emergence was calculated by using the following equation: adult emergence %= A/B×100. Where: A = number of emerged adults, B = number of tested pupae. All values calculated for each one and then the mean value was taken

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Adult females that succeeded to emerge from the 3rd instar larvae treated with each concentration were collected and transferred with untreated adult males obtained from the colony to the wooden cages (20×20×20 cm) by using an electric aspirator recommended by (WHO) and fed with dry diet (milk powder) and sucrose solution (cotton pads soaked in 10% sucrose solution) for four days. The eggs were counted by using binocular and then the mean values were taken. The Egg-hatchability percentage was calculated by using the following equation: Egg hatchability % = A/B×100. *Where:* A = total no. of hatched eggs, B = total no. of eggs laid. The Sterility percentage was estimated according to the formula of (Toppozada *et al.*1966): Sterility percentage = 100 – [a×b /A×B] ×100.

Standard cages (20×20×20cm) were used to test the repellent activity of plant extracts. Cotton pieces soaked in 10% sucrose solution from each concentration added to the wooden cages containing 40 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 $Tween_{80}$. 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] ×100. *Where:* A = percent of unfed females in treatment, B = percent of unfed females in control.

4. Statistical analysis.

Statistical analysis of the data was carried out according to the method of (Lentner *et al.*, 1982). The analysis was revised and graphics were drawn by Excel for Microsoft office 2010.The obtained data were assessed by calculation of the mean (M) and standard deviation (SD). The LC_{50} was calculated using multiple linear regression (Finney, 1971).

Results

1- Biological activity of *C. sempervirens* against *M. domestica*.

1-1- Ethanolic extract.

Data given in (Table 1) shows the effect of ethanol extract of *C. sempervirens* (leaves) against different biological aspects of *M. domestica.* The larval mortality percent and the mean larval duration were concentration-dependent. There was a negative correlation between the P% and the concentration used. The mortality percent of pupae were recorded 12.5, 11.8, 8.4 and 8.7% at the concentrations of 2000, 1700, 1400 and 1100 ppm; respectively.

Table (1): Effect of ethanol extract of *C. sempervirens* (leaves) on some biological aspects of *M. domestica.*

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Larval and Pupal mort. %	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
2300	100.0	--	--	--	--	100.0	0.0	--	--
2000	84.0	4.2±0.3[d]	16.0	12.5	4.6±0.2 [a]	96.4	87.5	8.8±0.5 [a]	9.9
1700	68.0	3.7±0.11[c]	32.0	11.8	4.0±0.7 [a]	79.6	88.2	7.7±0.8 [a]	11.5
1400	52.0	3.5±0.20[b]	48.0	8.4	4.3±1.1 [a]	60.4	91.6	7.9±1.5[a]	11.6
1100	36.0	3.2±0.19[a]	64.0	8.7	3.8±0.3 [a]	44.5	91.3	7.0±1.0 [a]	13.0
800	20.0	3.0±0.12[a]	80.0	0.0	4.1±0.6 [a]	20.0	100.0	7.1±1.61 [a]	14.1
Control	2.8	2.9±0.19	97.2	0.0	3.9±0.45	2.8	100.0	6.8±0.64	14.7

Conc.: concentration, ppm : part per million, means with different letter are significantly different (P<0.05).

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The mean pupal duration was non-significantly (P>0.05) affected. The adult emergence % was recorded 87.5 % for adults resulted from larvae treated with 2000 ppm and this percent was increased as the concentrations decreased. The growth index for larvae and pupae was not affected at all concentrations used as compared with the control group.

Table (2): Effect of ethanol extract of *C. sempervirens* (stems) on some biological aspects of *M. domestica.*

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
2300	**100.0**	**--**	**--**	**--**	**--**	**0.0**	**--**	**--**
2000	**84.0**	**4.2±0.37** [b]	**16.0**	**0.0**	**3.8±0.22** [a]	**100.0**	**8.0±0.59** [a]	**12.5**
1700	**62.8**	**3.7±0.12** [a]	**37.2**	**0.0**	**4.0±0.20** [a]	**100.0**	**7.7±0.32** [a]	**13.0**
1400	**38.8**	**3.5±0.40** [a]	**61.2**	**0.0**	**4.0±0.13** [a]	**100.0**	**7.5±0.53** [a]	**13.3**
1100	**29.2**	**3.2±0.78** [a]	**70.8**	**0.0**	**3.8±0.28** [a]	**100.0**	**7.0±1.06** [a]	**14.3**
800	**16.0**	**3.0±0.93** [a]	**84.0**	**0.0**	**4.1±0.14** [a]	**100.0**	**7.1±1.07** [a]	**14.1**
Control	**8.0**	**2.9±0.24**	**92.0**	**0.0**	**3.9±0.19**	**100.0**	**6.8±0.43**	**14.7**

See footnote of table (1).

The effect of ethanol extract of *C. sempervirens* (stems) against different biological aspects of *M. domestica* given in (Table 2). Complete larval mortality 100.0% was caused at the highest concentration 2300ppm, meanwhile the lowest value 16.0% was occurred at the lowest concentration used 800ppm compared to 8.0% for the control group. The larval duration was insignificantly (P>0.05) affected by all concentrations used except the highest concentration 2000 ppm, which prolonged it to 4.2±0.37 (days) against the control group. There was a negative correlation between the pupation % and the concentration used. The pupal mortality % was insignificantly (P>0.05) affected by all concentrations used. The growth index for larvae and pupae was not affected at all concentrations used as compared with the control group.

1-2- Acetone extract.

The biological activity of acetone extract of *C. sempervirens* (leaves) against the 3rd instar larvae of *M. domestica* was recorded in (Table 3). Results obtained revealed that, the larval mortality % was concentration-dependent; the highest larval mortality % (100.0) was caused by the concentration 1500 ppm. The larval duration was insignificantly (P>0.05) affected by all concentrations used. A reduction in pupation % was recorded at all concentrations used.

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Table (3): Effect of acetone extract of *C. sempervirens* (leaves) on some biological aspects of *M. domestica*.

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
1500	100.0	--	--	--	--	0.0	--	--
1300	89.2	1.9±0.10 [c]	10.8	74.1	3.8±0.25[d]	25.9	5.7±0.35 [d]	4.5
1100	72.0	2.5±0.24 [a]	28.0	56.0	3.9±0.23 [d]	44.0	6.4±0.47 [c]	6.9
900	48.0	2.6±0.22 [a]	52.0	76.9	3.7±0.19 [d]	23.1	6.3±0.41 [c]	3.7
700	36.0	2.8±0.17 [a]	64.0	68.8	3.8±0.11 [d]	31.2	6.6±0.28 [c]	4.7
500	22.8	3.0±0.23 [a]	77.2	62.2	3.8±0.14 [d]	37.8	6.8±0.37 [b]	5.6
Control	6.8	2.8±0.41	93.2	0.0	5.4±0.29	100.0	8.2±0.70	12.2

See footnote of table (1).

There was a toxic effect of acetone extract on the pupae resulted from treated larvae, the highest pupal mortality % (74.1 %) was induced at the concentration 1300 ppm. The pupal duration was significantly ($P<0.05$) affected by all concentrations used. A sharp reduction in AE % among the adults developed from the treated larvae at all concentrations was exhibited. A very retarded effect on growth of larvae, pupae and adult was observed especially at the highest concentration 1300ppm.

Data given in (Table 4) shows the biological activity of acetone extract of *C. sempervirens* (stems) against the 3rd instar larvae of *M. domestica.* The highest larval mortality % (100.0 %) was occurred at the concentration of 1500 ppm, while the lowest percent 17.2 %was occurred at the concentration of 500 ppm. The larval duration was insignificantly ($P>0.05$) affected by all concentrations used except the highest concentration 1300ppm.

Table (4): Effect of acetone extract of *C. sempervirens* (stems) on some biological aspects of *M. domestica*.

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
1500	100.0	--	--	--	--	0.0	--	--
1300	90.8	1.9±0.10 [b]	9.2	10.6	3.8±0.29 [a]	89.4	5.7±0.39 [a]	15.7
1100	69.2	2.5±0.24 [a]	30.8	10.0	3.9±0.21 [a]	96.1	6.4±0.45 [a]	15.0
900	48.0	2.6±0.19 [a]	52.0	9.5	3.7±0.14 [a]	90.5	6.3±0.33 [a]	14.4
700	30.8	2.8±0.33 [a]	69.2	0.0	3.8±0.10 [a]	100.0	6.6±0.43 [a]	15.2
500	17.2	2.7±0.15 [a]	82.8	0.0	3.8±0.15 [a]	100.0	6.5±0.30 [a]	15.4
Control	12.0	2.7±0.27	88.0	7.7	4.6±0.65	92.3	7.3±0.92	12.6

See footnote of table (1).

There was a negative correlation between the pupation % and the concentration used. No significant effect on the pupal duration was recorded. The growth index did not affected by acetone extract at all concentrations used as compared with the control group.

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1-3- Petroleum ether extract.

Table (5): Effect of Petroleum ether extract of *C. sempervirens* (leaves) on some biological aspects of *M. domestica.*

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
1000	100.0	--	--	--	--	0.0	--	--
800	84.0	4.2±0.22 [a]	16.0	81.1	7.3±0.41 [c]	18.9	11.5±0.63 [c]	1.6
600	66.7	3.9±0.18 [a]	33.3	84.3	6.9±0.19 [c]	15.7	10.8±0.37 [c]	1.5
400	53.3	3.3±0.36 [a]	46.7	73.2	7.1±0.91 [c]	26.8	10.4±1.27 [b]	2.6
200	28.0	2.8±0.21 [a]	72.0	59.7	6.6±0.78 [c]	40.3	9.4±0.99 [a]	4.3
Control	12.0	2.7±0.27	88.0	7.7	4.6±0.65	92.3	7.3±0.92	12.6

See footnote of table (1).

Data given in (Table 5) indicated the biological activity of petroleum ether extract of *C. sempervirens* (leaves) against the 3rd instar larvae of *M. domestica*. Complete larval mortality % (100.0%) was caused at the highest concentration used 1000ppm. Meanwhile, the LM % decreased to 28.0 at the lowest concentration 200 ppm. The larval duration was insignificantly (P>0.05) affected by all concentrations used. The pupation % was 0.0 at the highest concentration 1000 ppm and 72.0 at the lowest concentration 200ppm. A toxic effect on the pupae resulted from treated larvae was observed. The pupal duration affected by petroleum ether extract tested. A remarkable reduction in the adult emergence % was also observed. The growth index was greatly affected by tested extract.

On the other hand, the biological activity of stems petroleum ether extract was revealed in (Table 6).

Table (6): Effect of Petroleum ether extract of *C. sempervirens* (stems) on some biological aspects of *M. domestica.*

Conc. ppm	Larval mort. %	Larval duration	Pupation %	Pupal mort. %	Pupal duration	Emergence % (a)	Developmental Period (b)	Growth Index (a/b)
1000	100.0	--	--	--	--	0.0	--	--
800	84.0	3.9±0.98 [a]	16.0	100.0	--	0.0	--	--
600	66.7	3.5±0.12 [a]	33.3	47.6	4.0±0.7 [a]	52.4	7.7±0.8 [a]	6.8
400	53.3	3.4±0.96 [a]	46.7	47.3	4.3±1.1 [a]	52.7	7.9±1.5[a]	6.7
200	28.0	2.9±0.23[a]	72.0	27.6	3.8±0.3 [a]	72.4	7.0±1.0 [a]	10.3
Control	6.8	2.2±0.40	93.2	0.0	4.5±0.21	100.0	6.7±0.61	14.9

See footnote of table (1).

Data obtained showed that, the larval mortality% was concentration-dependent. The larval duration was insignificantly prolonged at all the concentrations used. The pupation% of the treated larvae was decreased as the concentration increased. The pupal mortality% and adult emergence% were found to be affected by extract used. The pupal duration was insignificantly (P>0.05) affected by all concentration used as compared with

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the untreated group. The growth index was greatly affected by petroleum ether stems extract, where it recorded 6.8, 6.7 and 10.3 at the concentrations 800, 700 and 600ppm; respectively, compared to 14.9 for the control group.

From the aforementioned results and based on the LC_{50} values Fig. (1) it is obvious that, the toxicity values of the tested ethanolic, acetone and petroleum ether extracts of *C. sempervirens* (leaves and stems) may be arranged in a descending order as follows: Petroleum ether extract > Acetone extract > Ethanolic extract.

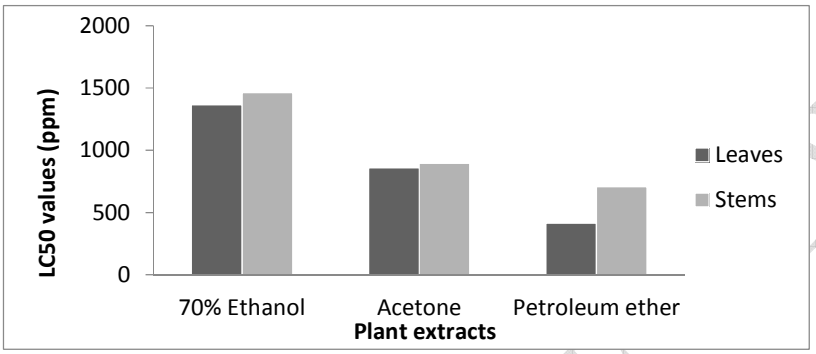

Fig. (1): LC_{50} values for ethanol, acetone and petroleum ether extracts from leaves and stems of *C. sempervirens* against 3rd instar larvae of *M. domestica*.

2- Reproductive potential.

The fecundity of females resulted from the larvae treated with leaves petroleum ether extract of *C. sempervirens* was significantly (P<0.001) decreased from 42.3±1.7 eggs/female at the lowest concentration 200 ppm to 38.0±1.4 at the highest concentration 800 ppm compared to 58.8±2.1 eggs/ female for control (Table 7). There was a slight decrease in the hatchability percent of eggs laid by females resulted from treated larvae. Also, a marked increase in the percentage of sterility for all females emerged from treated larvae was recorded.

Table (7): Effect of petroleum ether extract of *C. sempervirens* (leaves) on fecundity, fertility and sterility index of female *M. domestica*.

Conc. (ppm)	No. of tested females	Fecundity		Hatched eggs		Non-hatched eggs		Sterility Index (SI)
		Total	Mean±SD	Total	%	Total	%	
800	2	76	38.0±1.4 [d]	72	94.7	4	5.3	38.2
600	4	159	39.8±1.7[d]	154	96.8	5	3.2	33.9
400	7	291	41.6±2.1[d]	283	97.3	8	2.7	30.5
200	8	338	42.3±1.7[d]	332	98.2	6	1.8	28.7
Control	18	1059	58.8±2.1	1049	99.1	10	0.9	0.0

See footnote of table (1).

On the other hand, the fecundity of females resulted from the larvae treated with stems petroleum ether extract of *C. sempervirens* was decreased by increasing the concentration and the statistical analysis revealed that, there was a significant (P<0.001) decrease in the mean number of eggs laid by females resulted from treated larvae at the all

concentrations used (Table 8). A marked decrease in the hatchability percent and remarkable increase in the percentage of sterility index were also recorded.

Table (8): Effect of petroleum ether extract of *C. sempervirens* (stems) on fecundity, fertility and sterility index of female *M. domestica*.

Conc. (ppm)	No. of tested	Fecundity		Hatched eggs		Non-hatched eggs		Sterility Index (SI)
		Total	Mean±SD	Total	%	Total	%	
900	2	77	38.5±2.1[d]	73	94.8	4	5.2	39.0
800	3	117	39.3±1.2[d]	111	94.9	6	5.1	37.7
700	6	264	44.1±3.3[d]	253	95.8	11	4.2	29.4
600	7	327	46.7±1.7[d]	318	97.2	9	2.8	24.1
Control	20	1205	60.2±2.9	1198	99.4	7	0.6	0.0

See footnote of table (1).

3- Antifeedant and repellency activities.

The antifeedant and repellent activity of ethanolic, acetone and petroleum ether leaves extracts of *C. sempervirens* was shown in (Table 9), data obtained revealed that at the LC_{50} concentrations, the repellency percent recorded 45.6, 61.4 and 78.9 % for the tested extracts; respectively as compared with the untreated group.

Table (9): Effect of LC_{50} concentration from ethanol, acetone and petroleum ether extracts of *C. sempervirens* (leaves) as antifeedant or repellent for *M. domestica*.

Extract	LC_{50} value	Fed No.	Fed%	Non-fed No.	Non-fed %	Repellency action (%)
70% Ethanol	1363.0	10.3±0.64	51.7±2.91	9.7±0.63	48.3±2.92	45.6
Acetone	860.4	7.3±1.23	36.7±5.80	12.7±1.24	63.3±5.74	61.4
Petroleum Ether	412.01	3.6±1.52	18.3 ±7.63	16.3 ±1.53	80.0±5.01	78.9
Control	0.0	19.0±1.20	95.0 ±5.01	1.0 ±1.12	5.0±5.03	0.0

In contrast, the antifeedant and repellent activity of ethanolic, acetone and petroleum ether stems extracts of *C. sempervirens* against starved *M. domestica* adults were varied according to the solvents used in extraction (Table 10).

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Table (10): Effect of LC_{50} concentration from ethanol, acetone and petroleum ether extracts of *C. sempervirens* (stems) as antifeedant or repellent for *M. domestica*.

Extract	LC_{50} value	Fed No.	Fed%	Non-fed No.	Non-fed %	Repellency action (%)
70% Ethanol	1462.5	14.7±1.54	73.3±7.61	5.3±1.52	26.7±7.63	21.4
Acetone	893.7	10.7±1.51	53.3±7.63	9.3±1.54	46.7±7.61	42.9
Petroleum Ether	706.1	5.3±1.20	26.7±5.82	14.7±1.21	73.3±5.84	71.4
Control	0.0	18.7±1.52	93.3 ±7.64	1.3 ±1.51	6.7±7.60	0.0

The petroleum ether extract was more effective than acetone and ethanolic extracts during the entire testing period of 2h post treatment. The repellency was 71.4% for the petroleum ether extract, while it recorded 42.9 and 21.4% for acetone and ethanolic extracts; respectively compared with the control group.

Discussion and conclusion

The plant tested in this study is known to be eco-friendly and non-toxic to vertebrates (EL-Sheikh *et al.*, 2011). Moreover, it is clearly proved that crude or partially purified plant extracts are less expensive and highly efficacious for the control of *M. domestica* rather than the purified compounds or extracts (Jang *et al*., 2002 and Cavalcanti *et al*., 2004). The results of this study may offer an opportunity for developing alternatives to rather expensive and environmentally hazardous organic insecticides.

An insecticide dose not has to cause high mortality on target organisms in order to be acceptable. Sukumar *et al*., (1991) suggested the existence of variations in toxicities of phytochemical compounds on target species depending on the plant part from which they were extracted. In addition, Maurya *et al.,* (2009) noted that other variations were due to responses by species and developmental stages of species to the specified extract, solvent of extraction, geographical origin of the plant, photosensitivity of compounds in the extract, effect on growth and reproduction and other factors. The larval mortality percent was increased as concentration increased for all extracts tested. Based on LC_{50} values, the toxicity tested of ethanolic, acetone and petroleum ether extracts of leaves were more effective than those of stems. Also, the petroleum ether extracts were more effective than acetone and ethanolic extracts for all plant parts used. These results are in agreement with the previously mentioned suggestions of Maurya *et al*., (2009).

Different extracts tested varied the larval and pupal duration depending on plant part, solvent and concentration of the extract. Prolongation of the larval duration was similar to that reported in *M. domestica* by Gad-Allah, (1991), using *Melia azedarach*, Ande, (2001) using *Peganum harmala, Acalypha indica* and *Calotropis gigantic* and El-bermawy *et al*. (2011) for *Cupressus macrocarpa* (leaves) powders. Prolongation in the pupal duration was also recorded in this study, Similar observation was also recorded on *M. domestica* by Assar, (2003) using *Atriplex inflate* and Bakr *et al.* (2003) using *Artemisia monosperma*. The pupation rate was varied according to plant part and solvent used in extraction, moreover, the pupation percent was decreased as the concentration of plant extract increased. Similar effects of some botanical plant extracts have been reported on *M. domestica* by (Ande, 2001; Assar, 2003; Bakr *et al*. 2003 and El-bermawy *et al*.2011).

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The decrease in the percentage of adult emergence of *M. domestica* due to treatment with the tested plant extracts was similar to those of Muse *et al*., (2003) where, the mean number of males and females of *Chrysomya chloropyga* emerging from larvae feeding diet containing 5 % of *Lantana camara* powder, were significantly less than those of the control, Khalaf *et al*., (2009) who found that, high reduction in *Synthesiomyi anudiseta* adult emergence was induced by larval treatment with *C. macrocarpa* volatile oils. The growth index of *M. domestica* was clearly affected by the plant extracts tested. It decreased as the concentration increased. Retardation in growth was induced by different parts of plant tested, such results are in agreement with earlier studies using different plant extracts against other dipteran species by Jeyabalan *et al*. (2003) using *Pelargonium citrosa* leaf extracts on *Anopheles stephensi*, Nathan *et al*. (2006) using *Melia azedarach* on *A. stephensi* and Sharma *et al*. (2006) sing *Artemisia annua* extract against *Culex autnauetesctetus*.

The results obtained also indicated that, treatment of *M. domestica* larvae with plant extracts caused a decrease in egg production. Different authors reported some illustrations revealing the possible reasons for the reduction of fecundity and as a result increasing sterility following the treatment with plant extracts. The weakened physical stage of the treated insects (Tripathi *et al*., 2003). Mild suppressing effect exerted by the plant extract on the insect's mating-decisive factor influencing the subsequent number of eggs laid by the insect (Engelmann, 1970). Partial sterilization of females and/or males, or the inability of the sperms to be transferred to the females during copulation (Ismail, 1980). Reduction in the number of normal sperms produced by a male insect (El-Meniawi *et al*., 1999).Blockage of ovarian activity, as the tested botanical products may interfere with oogenesis, which in turn, results in a complete and irreversible sterility of insect female flies (Khan *et al*., 2007).

Reduction in the egg hatching percent by plant extracts was similar to findings reported by many authors against *M. domestica*, among these are *Melia azedarach* extract Radwan, (2000), leaves and flowers extracts of *Datura innoxia* Al-Zubaidi *et al*., (2002), *A. inflate* Assar, (2003). Tested 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 and the petroleum ether extract was more effective in repellent action as compared with the acetone and ethanol extracts, These results are in consistence with Bisseleua *et al*. (2008) using petroleum ether extracts of *Griffonia simplicifolia*.

It could be concluded that toxicity of tested extracts varied according to a plant part, the solvent used in extraction and concentration of the extract. Based on LC_{50}, the toxicity values were arranged as follows: leaves > stems. Petroleum ether extract from leaves was more effective in inducing the fecundity, antifeedant, repellent actions and egg-hatchability than those from stems. So, the plant extracts used may be considered as new promising controlling agents for the housefly, *M. domestica*.

Ethical Approval:

As per international standard or university standard ethical approval has been collected and preserved by the authors.

References

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Al-Zubaidi, FS, Al Rubaie, HM and Al Okaily, LN (2002): The effects of terpenoid compounds extracted from *Datura innoxia* Mill on the biological performance of *Musca domestica* L. (Diptera: Muscidae). *Proc. of the 2nd. Inter. Conf. on Biological Sciences, Fac. Sci. Tanta Univ.*

Ande, AT (2001): Biological activities of some plant materials against the housefly, *Musca domestica*. *Ni. S. Exp. Bio. J.* 1(4):293-296.

Assar, AA (2003): Biological effects of the water extract of *Atriplex inflate* (Chenopodiaceae) on the housefly, *Musca domestica* vicina. (Diptera: Muscidae). *J. Egypt. Ger. Soc. Zool.* 41 (E): 15-28.

Bakr, ME, Nassef, NE, Assar, AA, El-Sobky, MM and Shams El-Din, SA (2003): Biological and morphological effects of water extracts of some plants on the housefly, *Musca domestica vicina*. (Diptera: Muscidae). *J. Egypt. Ger. Soc. Zool*. 41 (E): 29-47.

Bisseleua, HBD, Gbewonyo, SWK and Obeng-Ofori, D. (2008): Toxicity, growth regulatory and repellent activities of medicinal plant extracts on *Musca domestica* L. (Diptera: Muscidea). *Afr. J. Biot.* 7(24): 4635-42.

Busvine, JR (1962): A laboratory technique for measuring the susceptibility of houseflies and blow flies to insecticides. *Lab. Prot. London*. (11): 464-468.

Cavalcanti, ES, Morais, SM, Lima, MA and Santana, EW (2004): Larvicidal activity of essential oils from Brazilian plants against *Ae. aegypti* L. *Mem. Inst. Oswaldo. Cruz*. 99(5): 541-544.

De Jesús, AJ, Olsen, AR, Bryce, JR and Whiting, RC (2004): Quantitative contamination and transfer of *Escherichia coli* from foods by houseflies, *Musca domestica* L. (Diptera: Muscidae). *Inter. J. Food Microbial*.93: 259-262.

El-bermawy, SM, Elkattan, NAI, Ahmed, SK and Abdel-Gawad, RM (2011): Screening for bioactive materials against housefly, *Musca domestica* L. (Diptera: Muscidae). *Functional Plant Biotech*. 5(1): 45-51.

El-Meniawi, FA, Hashem, M, El-Mesieri, SM and Rawash, IA (1999): Physiological effects of neem seed extracts on the reproductive activities of the cotton leaf worm, *Spodoptera littoralis* Boisd. *Alex. J. Agric. Res.* 44(1): 79-96.

EL-Sheikh, TMY, Hassan, MI, Moselhy, WA, Amer, MS and Shehata, AZ (2011): Evaluation of the biological activity of *Cupressus sempervirens* (Cupressaceae) extracts against the mosquito vector *Culex pipiens* L. (Diptera: Culicidae). *Egypt. Acad. J. biolog. Sci*., 4 (1): 33 - 48

Engelmann, F (1970): The Physiology of Insect Reproduction. *Pergamon Press. New york.*

Finney, DJ (1971): Probit analysis Third edition. *Cambridge Univ. Press.* 333 p.

Gad-Allah, SZ (1991): The effect of some plant extracts on *Musca domestica* vicina. *Unpublished M. Sci. Thesis, Fac. Sci., Cairo Univ., Egypt.*

Hanan, BA (2013): Evaluation of insecticidal activities of *Mentha piperta* and *Lavandula angustifolia* essential oils against housefly, *Musca domestica* L. (Diptera: Muscidae). *J. Entomol. Nematol*. 5: 50-54.

Ismail, IE (1980): Physiological studies on the effect of juvenile hormone analogues upon the cotton

UNDER PEER REVIEW

leaf worm *Spodoptera littoralis* Boisd (Lep., Noctuidae) . *Unpublished Ph.D. Thesis, Cairo, Univ. Egypt.*

Ito EE, Nmor, JC, Ake JEG, and Uteboe K (2015). Larvicidal activities of *Pistia stratiotes* (water lettuce) against 3rd and 4th instar larvae of *Aedes aegypti*. *Advances in Research*, 3(6): 589-595.

Ito EE and Ighere EJ (2017):Bio-insecticidal Potency of Five Plant Extracts against cowpea weevil, *Callosobruchus maculatus* (F.), on Stored Cowpea, *Vigna unguiculata* (L). *Jordan Journal of Biological Sciences*, 10(4): 34-39.

Jang, YS, Baek, BR, Yang, YC, Kim, MK and Lee, HS (2002): Larvicidal activity of leguminous seeds against *A. aegypti* and *C. pipiens* pallens. *J. Am. Mosq. Control Assoc*. 18(3): 210-213.

Jeyabalan, D, Arul, N and Thangamathi, P (2003): Studies on effects of *Pelargonium citrosa* leaf extracts on malarial vector, *A. stephensi* Liston. *Biores. Tech.* 89(2): 185-189.

Khalaf, AA, Hussein, KT and Shoukry, KK (2009): Biocidal Activity of two botanical volatile oils against the larvae of *Synthesiomyianudiseta* (Wulp) (Diptera: Muscidae). *Egypt Acad. J. Bio. Sci.* 2 (1): 89-101.

Khan, M. Hossain, MA and Islam, MS (2007): Effects of neem leaf dust and a commercial formulation of a neem compound on the longevity, fecundity and ovarian development of the melon fly, *Bactocera cucurbitae* (Coquillett) and the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). *Pak. J. Biol. Sci.* 10: 3656-61.

Khan, HAA, Shad, SA and Akram, W (2013): Resistance to new chemical insecticides in the housefly, *Musca domestica* L., from dairies in Punjub, Pakistan. *Parasito. Res.*12: 2049-54.

Khan, MF, Ahamad, T and Rawat, P (2017): Biomedicinal and chemical profile of *Cupressus sempervirens*: A Mini Review. Insights Biomed. 2: 3-16.

Kumar, PS, Mishra, A and Malik, SS (2012): Housefly (*Musca domestica* L.) control potential of *Cymbopogon citratus* Staff (Poales: Poaceae) essential oil and monoterpenes. *Parasitol Res*. 112: 69-76.

Lentner, C, Lentner, C and Wink, A (1982): Students t-distribution tables. In Geigy scientific Tables Vol. 2.International Medical and Pharmaceutical information, Ciba–Geigy Limited, Basal, Switzerland.

Maurya, P, Sharma, P, Mohan, L, Batabyal, L and Srivastava, CN (2009): Evaluation of the toxicity of different phytoextracts of *Ocimum basilicum* against *Anopheles stephensi* and *Culex quinquefasciatus*. *Journal of Asia-Pacific Entomology*.12: 113-115.

Morey, RA and Khandagle, AJ (2012): Bioeffeicacy of essential oils of medicinal plants against housefly, *Musca domestica* L. *Parasito. Res*. 111: 1799-05.

Murugesan, S, Kumar, NS, Babu, DS and Rajasugunasekar, D (2016): Chemical constituents and toxicity assessment of the leaf oil of *Lantana camara* Linn from Tamilnadu regions. *Asian J. Plant Sci. Res.* 6(3): 32-42.

Muse, WA, Lajide, L and Adediri, CO (2003): Effect of some Nigerian plants on survival, oviposition, and emergence of adult blowfly, *Chrysomya chloropyga* (Wied.) (Diptera: Calliphoridae). *J. Asia-Pacific Entomol.* 6 (1): 69-75.

UNDER PEER REVIEW

Nathan, SS, Savitha, G, George, DK, Narmadha, A, Suganya, L and Chung, PG (2006): Efficacy of *Melia azedarach* L. extract on the malarial vector *A. stephensi* Liston (Diptera: Culicidae). *Biores. Tech.* 79: 1316-23.

Radwan, MEH (2000): Effect of crude methanolic extracts of leaves and fruits of chinaberry tree *Melia azedarach* L. on the adult female housefly *Musca domestica vicina*. *Unpublished M.Sc. Thesis, Fac. Sci. Alex. Univ., Egypt.*

Sharma, P, Mohan, L and Srivastava, CN (2006): Growth inhibitory nature of *Artemisia annua* extract against *Culex autnauetesctetus* (Say). *J. Asia-Pacific Entomol.* 9(4): 389-395.

Singh, A, Singh, DK, Mishra, TN and Agarwal, RA (1996): Molluscicides of plant origin. *Biol. Agri. Horti*. 13: 205-252.

Sukumar, K, Perich, MJ and Boobar, LR (1991): Botanical derivatives in mosquito control: A review. *Am. Mosq. Contr. Assoc.* 7(2): 210-237.

Toppozada, A, Abdallah, S and El-Defrawi, ME (1966): Chemo-sterilization of larvae and adults of the Egyptian cotton leafworm, *Prodenialittura* by apholate, metepa and hempa. *J Econ. Entomol.*59: 1125-28.

Tripathi, AK, Prajapati, V, Khanuja, SPS and Kumar, S (2003): Effect of d-limonene on three stored-product beetles. *J. Econ. Entomol.* 96(3): 990-995.

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