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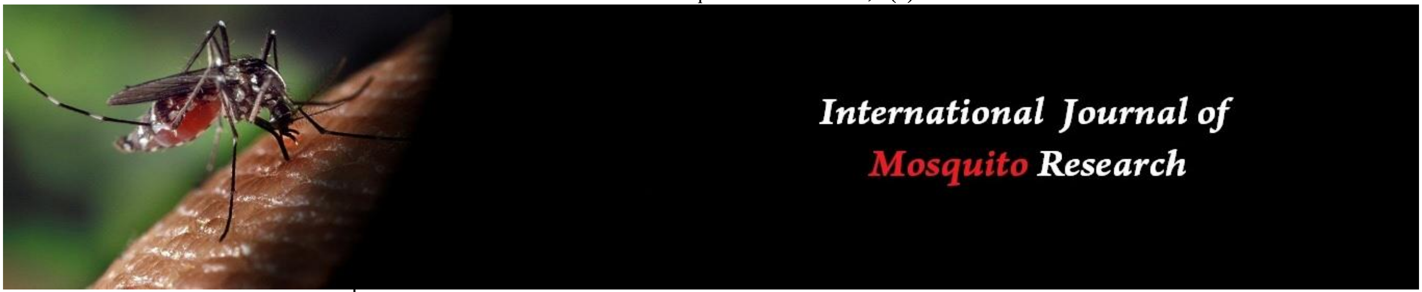

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Toxicological activity of four plant oils against *Aedes caspius* and *Culex pipiens* (Diptera: Culicidae)

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Abstract
The toxicological activity of four plant oils, *Matricaria chamomilla, Origanum majorana, Carum petroselinum and Salvia officinalis* were evaluated against all larval instars and pupae of *Aedes caspius* and *Culex pipiens*. The plant oils were tested at different concentrations of 100, 200, 400, 800 and 1600 ppm at different time intervals (24, 48 and 72hrs). The obtained results showed that, all tested plant oils had prominent mosquitocidal activity against *A. caspius* and *C. pipiens*. Mortality increased by increasing concentration and time of exposure. *M. chamomilla* showed highest larvicidal activity after 24 hrs. for all larval instars of *A. caspius* and *C. pipiens*. Higher mortality was observed in 1st instar larvae than all other immature life stages with all oils. The developmental periods were extremely prolonged after treatment with the lowest concentration of all used oils. Adult emergence was completely stopped at 800 ppm of *M. chamomilla* and *C. petroselinum* against *A. caspius*. It was concluded that, the used oils have toxic effects against larvae and pupae of *A. caspius* and *C. Pipiens*, altered developmental periods, pupal rate and adult emergence with superiority of *M. chamomilla* and *C. petroselinum*. It was recommended that, *M. chamomilla* and *C. petroselinum* have the potential to be used for larval and pupal control of *A. caspius* and *C. pipiens*.

Keywords: *Matricaria chamomilla, Origanum majorana, Carum petroselinum and Salvia officinalis*

Introduction
Mosquitoes are the most important hematophagous diptera in terms of public health importance, and major vectors for the severe and highly infection diseases to human such as malaria, filariasis, Japanese encephalitis, dengue and yellow fever etc., causing huge number of deaths around the world (Ghosh *et al.*, 2012; Kamatchi *et al.*, 2016) [11, 14]. WHO has described the mosquito as public enemy number one and reported mosquito-borne diseases across globally infecting more than 700,000,000 people every year (Meenakshi and Jayaprakash 2014) [21].
Culex pipiens is the most common mosquito species in Egypt (Shawarby *et al.* 1968, Soliman 1995, Khater and Shalaby 2008) [30, 33, 17] causing dreadful nuisance and transmitting many dangerous diseases. It is the main vector of filarial worm *Wuchereria bancrofti* as well as Rift valley fever virus (Ramzy *et al.* 2005, WHO 2012) [25, 37].
Aedes caspius is a potential reservoir of Rift Valley Fever Virus (RVF) during interepizootic periods and it is a vector of the Tahyna (TAH) virus in the Mediterranean region (Balenghien *et al.*, 2006; Kamal, 2011) [5, 13].
Mosquito control is a necessary measure to improve environmental quality and public health. The controlling strategies are largely based on synthetic chemical substances. Synthetic organic chemical insecticides were used since long for the control of these vector mosquitoes, resulted in development of resistance, residue contamination of human food, mammalian toxicity and environmental pollution (Domingues *et al.*, 2010; Singh *et al.*, 2014) [8, 32]. Therefore, we need to seek for safe insecticides, or natural products which can be a reliable and environment ecofriendly source of raw materials for that purpose.
According to available literature, studies were carried out for control of mosquitoes using plant oils (Amer and Mehlhorn 2006; Madkour *et al.* 2014; Yadav 2014; Nasir *et al*. 2015;

Reiner *et al*., 2016; Sharma *et al*., 2016) [4, 19, 35, 22, 26, 29] but none of them used *M. chamomilla, O. majorana, C. petroselinum and S. officinalis* against *A. caspius* and *C. Pipiens*.Therefore, the aim of this study was to investigate the toxic effect of different concentrations of *M. chamomilla, O. majorana, C. petroselinum and S. officinalis* plant oils on all larval instars and pupae of *A. caspius* and *C. pipiens* as well as, the alteration of some biological aspects following treatment with sub-lethal concentrations of the tested oils**.**

Materials and Methods

1. Plant oils

The plant oils; Chamomile Oil (*M. chamomilla*), Marjoram oil (*O. majorana*), parsley (*C. petroselinum*) and Sage oil (*S. officinalis*) were purchased from Agro Green Company and reserved in dark glass bottles at a low temperature (15 °C) until use.

2. Mosquito culture

Mosquito larvae were collected from stagnant water mosquito breeding in various places in Prince Village, Qalyubiya Governorate, Egypt. The collected larvae were identified according to Harbach (1985) [12]. The collected larvae were colonized and maintained continuously for three generations in the laboratory free of exposure to insecticides in dechlorinated water. The colonies were maintained at 27 ± 2°C, 72-83% RH under a photoperiod of 14:10 h (light/dark) in the insectary of Entomology Department, Faculty of Science, Benha University according to El-Bokl and Moawad (1996) [9] and Adham *et al*., (2003) [2]. Two developmental stages, larvae and adult females, were continuously available for the experiments and were maintained at the same laboratory conditions (Baz, 2013) [26].

3. Bioassays of the tested oils

Bioassays were performed with first, second, third and fourth instar larvae and pupae of *A. caspius and C. pipiens*. The plant oils of *M. chamomilla*, *O. majorana*, *C. petroselinum* and *S. officinalis* were tested at 100, 200, 400, 800 and 1600 ppm concentrations. Twenty-five larvae per concentration were transferred to 500 ml glass beaker containing 250 ml of dechlorinated water used for all the experiments. Plant oils were dissolved with an emulsifier (0.1% Tween 80). The experiment was replicated five times with untreated control groups. Mortalities were recorded after 24, 48 and 72 hrs. of exposure period WHO (1981) [36].

Larval mortality counts were determined daily until pupation in order to determine LC_{50} and LC_{90} values. Dead larvae were identified when they failed to move after probing with a needle in the siphon or cervical region. Larvae were also observed for discoloration and unnatural positions. The developmental periods, pupation rates and adult emergences were determined for each plant oil concentration.

Statistical analysis

Statistical analysis was carried out using ANOVA with five factors under significance level of 0.05 for the whole results using SPSS (ver. 22). Data were treated as complete randomization design according to Steel *et al*. (1997) [34]. Multiple comparisons were carried out applying LSD. Statistical data analysis regarding LC_{50}, LC_{90} and slope were calculated using Finney (1971) [10] Probit analysis software.

Results

The present results showed that, mortality percentage in larvae of both mosquito species increased by increasing concentration and time of exposure. Data given in table (1) indicated that, the highest mortality was observed in first instar larvae than almost all other immature life stages at the highest concentration of all used oils. 100% and 96.8% mortalities were obtained for the 1st instar larvae of *A. caspius* and *C. pipiens* after 24 hrs exposure to 1600 ppm of *M. chamomilla* oil compared to 1.6% and 0.8% mortality for the control respectively, followed by 99.2% and 93.6% mortalities after treatment with *C. petroselinum* oil at the same concentration for *A. caspius* and *C. pipiens* respectively. On the other hand, the lowest mortalities were recorded in *S. officinalis* oil, 88% and 80% for the 1st instar larvae of *A. caspius* and *C. pipiens* respectively.

Results in table (2) revealed that, 100% mortality of the first instar larvae of *A. caspius* and *C. pipiens* was observed after 48 hrs exposure in all oils except for *S. officinalis*. 100% mortality of the second instar larvae of *A. caspius* and *C. pipiens* was recorded after exposure to 1600 ppm of *M. chamomilla, C. petroselinum*. Results in table (3) showed that after 72 hrs, 100% mortality of the first instar larvae was seen for both vector mosquitoes at the highest concentration compared to 1.6% mortality in the control group.

Tables 1, 2 & 3 indicated that *A. caspius* larvae were more susceptible than *C. pipiens* larvae. It was also observed that, there are significant differences between toxicities of different oils against larval instars of *A. caspius* and *C. pipiens*, where the highest potential larval mortality was observed in *M. chamomilla* against both mosquito species, the mean toxicities of the oil after 24, 48 & 72 hrs were 8.2, 10.5 and 12.9 followed by *C. petroselinum*, 8.1, 10.1and 12.8respectively, while *S. officinalis* was the least effective.

Table (4) revealed that LC_{50} values of *M. chamomilla* were 514 and 532 ppm at 24 hrs. and at 48 hrs., LC_{50} were 310 and 316 ppm, while at 72 hrs, LC_{50} values were 197 and 188 ppm for the first instar larvae of *A. caspius* and *C. pipiens* respectively. LC_{50} value of *S. officinalis* oil against second instar larvae at 24 hrs. was (802 ppm) *C. pipiens* followed by *O. majorana* (800 ppm). LC_{50} of *C. petroselinum* against third instar larvae was 623 ppm after 24 hrs., however *M. chamomilla* oil was found to be the best after 48 hrs. and 72 hrs. LC_{50} values were 430 and 278 ppm, respectively for *A. caspius* larvae. *C. petroselinum* was effective where the LC_{50} value was 649 ppm at 24 hrs, 463 ppm at 48 hrs. and 277 ppm at 72 hrs for the fourth instar larvae of *A. caspius*.

The pupicidal effect of the tested oils against *A. caspius* and *C. pipiens* were presented in table (5). Based on LC_{50} values, *C. petroselinum* and *O. majorana* proved as highly toxic to mosquito pupae and this response was time dependent. The LC_{50} values of *C. petroselinum* against *A. caspius* pupae were 640 ppm, 482 ppm and 330 ppm at 24, 48 and 72 hrs post-treatment respectively. LC_{50} values of *O. majorana* against *C. pipiens* pupae were 848 ppm at 24 hrs, 576 ppm at 48 hrs and 354 ppm at 72 hrs. On the other hand, *S. officinalis* was the least effective against both mosquito species where LC_{50} values were 1478 ppm and 1380 ppm at 24 hrs. post treatment for *A. caspius* and *C. pipiens*, respectively.

Table (6) showed that, larval and pupal durations were dose dependent and the developmental periods were extremely prolonged after treatment with the lowest concentration of all used oils. The longest larval and pupal periods were 24 & 9 days and 19 & 8 days after treatment of *C. pipiens* and *A. caspius* with *C. petroselinum* at 100 ppm, compared to 9 & 2 days and 8 & 2 days of the control respectively. On contrary at 800 ppm of almost all oils decreased larval periods. The percentages of pupation and adult emergence were greatly reduced especially at the highest concentrations. Adult emergence was completely stopped at 800 ppm of *M. chamomilla* and *C. petroselinum* against *A. caspius.*

Discussion

The obtained results showed that, all plant oils used showed prominent mosquitocidal activity against *A. caspius* and *C. Pipiens* larvae and pupae. The biological activity of such plant oils might be due to various compounds that exist in plants, including phenolics, terpenoids and alkaloids which may produce larvicidal and adult emergence inhibition activity against mosquitoes. These results are in accordance with (Pavela, 2008) [23], who studied the larvicidal activities of extracts from 56 species of plants in the Euro-Asiatic region against 4th larval instar of *Culex quinquefasciatus* and observed that, all plant extracts showed larvicidal activity after 24hrs of exposure in a maximal dose of 500 ppm.

The highest larvicidal activity was observed in *M. chamomilla*, LC_{50} values were 197, 232, 278 and 297 ppm after 72 hrs. for 1st, 2nd, 3rd and 4th instar larvae of *A. caspius* respectively. In this context, (Singh *et al.* 2011) [31] stated that *M. chamomilla* is a member of Asteraceae family which possesses various types of phytochemical compounds (flavonoids, sesquiterpines, thiophene derivatives). (Ribeiro *et al.* 1994) reported that those compounds have been found to be toxic to insects including mosquito larvae. Yadav *et al.* (2014) [35] evaluated the larvicidal efficacy of *Vernonia cinerea* extract against *Aedes albopictus* larvae and stated that the extract was highly effective because it is a member of Asteraceae family which possesses compounds toxic to mosquito larvae. Similarly, Abo El-Mahasen and Mahmoud (2016) [1] evaluated three plant oils; linseed (*Linum usitatissimum*), watercress (*Nasturtium officinale*) and black seed (*Nigella sativa*) as larvicidal natural agents against third instar larvae of *Cx. pipiens.* Their results showed that all the three tested oils induced larval mortality, watercress oil was the most effective followed by linseed and black seed oil and the effects were dose dependent and time of exposure.

The present study revealed that, mortality increased by increasing concentration and time of exposure, the highest mortality was observed at the highest concentration after 72 hrs. Our results agree with Remia and Logaswamy (2010) [27] who recorded that LC_{50} was 203.49 ppm for the fourth instar larvae of *A. aegypti* after 24 hrs. of exposure to *Lantana camara* and 230.76 ppm on *Catharanthus roseus* and the same concentration of plant extract gave 100% mortality after 96h post treatment. (Madkour *et al.* 2014) [19] investigated the activity of petroleum ether extracts of *Dodonaea viscosa*, L *camara* and *Ruta chalepensis* against 2nd instar larvae of *A. aegypti* at 2, 4 and 10 days post-treatment. The results showed acute LC_{50} (2 days) of 126.2 & 136.9 and chronic LC_{50} (10 days) of 64.6 & 68.5 ppm for *D. viscose* and *L camara* respectively. Prasad *et al.* (2014) [24] observed that, the LC_{50} value was 37.15 and 67.61 mg/l in *C. roseus* flowers and leaves, respectively after 24 hrs. of exposure time and 26.92 and 35.48 mg/l, respectively at 48 hrs. of exposure time. Nasir *et al.* (2015) [22] evaluated the efficacy of five essential oils against all larval instars and pupae of *A. aegypti* after 8, 16, 24 and 48 hrs. and observed that, the response of mosquito larvae and pupae was time and concentration dependent. Kamatchi *et al.* (2016) [14] investigated the toxic effect of *L. camara* and *C. roseus* against *C. quinquefasciatus* and *A. aegypti*. 100% mortality was observed at the highest concentration (1000 ppm) against the four larval instars of both vectors.

The findings of the present investigation revealed that higher mortality was observed in early instars than later ones and *A. caspius* was more susceptible than *C. pipiens*. These findings corroborate with earlier findings of Kumar and Maneemegalai (2008) [18] who observed maximum mortality in *A. aegypti* exposed to *L. camara* for 24 hrs. than *C. quinquefasciatus* and the 3rd instar larvae were more susceptible than 4th instar. Maheswaran *et al.* (2008) [20] reported that the first and second instar larvae of *C. quinquefasciatus* and *A. aegypti* were highly sensitive when compared with third and fourth instar larvae treated with *Leucas aspera* crude extract. Nasir *et al.* (2015) [22] noticed that the higher mortality was observed in early life stages than later ones. Kamatchi *et al.* (2016) [14] recorded that LC_{50} values of *C. roseus* were 30.28, 38.01, 59.12 & 71.81 and 26.64, 34.64, 53.10 & 72.89 ppm against first, second, third & fourth instar larvae of *C. quinquefasciatus* and *A. aegypti*, respectively.

The current study showed that, the developmental periods were extremely prolonged after exposure to the lowest concentrations of all used oils. The prolongation might be due to the effect of these oils on the tissues of insects. Khalaf (1998) [15] reported that, the total carbohydrates, protein and lipids decreased in the last instar larvae of *Galleria mellonella* caused by treating 3rd larval instar with some plant oils. Furthermore, in the current study the pupal rate and adult emergence were greatly reduced especially at the highest concentration. No adults emerged when the larvae of *A. caspius* were exposed to 800 ppm of *M. chamomilla* and *C. petroselinum* because all larvae and pupae died before developing into the adult stage. Therefore these plant oils were able to disrupt the biology of mosquitoes, in terms of prolonging the larval or pupal stages or prevent development into adult stage. Our results correspond with those reached by Khalaf (1999) [16] who found that, when the larvae of *C. pipiens* were treated with LC_{75} of essential oils of *L. camara* and *C. dioscoridis*, none succeeded to emerge to adult stage. Bream *et al.* (2009) [7] studied the effect of *Phragmites australis* extract against 2nd instar larvae and adults of *C. pipiens* and found a significant decrease in the percentage of pupation and adult emergence. Al-khalaf and Al-mehmadi (2010) [3] showed that LC_{50} of *Artemisia herba, M. chamomilla* and *Melia azedarach* led to a prolongation of 3rd larval instar of *C. quinquefasciatus* and affected proportions entering the pupal stage. Madkour *et al.* (2014) [19] demonstrated that *D. viscose* and *L. camara* caused significant high hindrance of subsequent larval development and consequently reduced both pupation and adult emergence.

Finally, it can be concluded that, plant oils, *M. chamomilla, O. majorana, C. petroselinum and S. officinalis* had a toxicological activity against larvae and pupae of *A. caspius* and *C. Pipiens*, altered developmental periods, pupal rate and adult emergence with superiority of *M. chamomilla* and *C. petroselinum*.

Table 1: Larvicidal effect of different concentrations of *M. chamomilla, O. majorana, C. petroselinum* and *S. officinalis* against of *A. caspius* and *C. pipiens* larvae after 24 hours.

Plant oils	**Conc. (ppm)**	**Mosquito larvae**										**Mean of oil**
		A. caspius					***C. pipiens***					
		1 st instar	**2 nd instar**	**3 rd instar**	**4 th instar**	**Mean**	**1 st instar**	**2 nd instar**	**3 rd instar**	**4 th instar**	**Mean**	
M. chamomilla	100	2.00±0.3e^{AB}	1.80±0.2^{eBC}	1.60±0.2^{eC}	2.20±0.4^{eA}	1.90±0.1^{e}	1.80±0.2^{eA}	1.40±0.4^{eB}	1.80±0.4^{eA}	1.40±0.4^{eB}	1.70±0.2^{e}	8.2±0.5^{a}
	200	4.60±0.2^{dA}	4.20±0.4^{dB}	4.60±0.9^{dA}	3.80±0.5^{dC}	4.30±0.3^{d}	4.20±0.4^{dA}	3.20±0.6^{dC}	3.80±0.7^{dB}	3.20±0.6^{dC}	3.70±0.3^{d}	
	400	8.60±0.9^{cA}	7.40±0.9^{cB}	7.40±1.1^{cB}	6.00±1.1^{cC}	7.40±0.5^{c}	7.40±0.7^{cA}	6.20±1.5^{cC}	6.60±0.7^{cB}	6.20±1.5^{cC}	6.50±0.5^{c}	
	800	15.2±0.9^{bA}	14.4±1.7^{bB}	14.0±0.5^{bC}	11.8±1.3^{bD}	13.9±0.6^{b}	15.0±0.9^{bA}	11.2±1.1^{bC}	13.8±1.2^{bB}	11.2±1.1^{bC}	12.7±0.6^{b}	
	1600	25.0±0.0^{aA}	24.6±0.4^{aB}	23.8±0.7^{aC}	20.8±1.2^{aD}	23.6±0.5^{a}	24.2±0.6^{aA}	22.0±0.9^{aC}	22.8±0.7^{aB}	22.0±0.9^{aC}	22.0±0.5^{a}	
	Control	0.40±0.4^{fA}	0.80±0.4^{fA}	0.40±0.2^{fB}	0.20±0.2^{fB}	0.60±0.2^{f}	0.20±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.30±0.1^{f}	
	Mean	9.30±1.6^{A}	8.90±1.6^{B}	8.80±1.5^{B}	7.50±1.3^{C}	8.6±0.7	8.80±1.6^{A}	7.40±1.4^{C}	8.20±1.5^{B}	7.40±1.4^{C}	7.8±0.7	
O.majorana	100	2.00±0.3^{eA}	1.60±0.2^{eB}	1.60±0.2^{eB}	1.00±0.3^{eC}	1.6±0.2^{e}	1.40±0.4^{eB}	1.20±0.4^{eB}	0.60±0.2^{eC}	1.20±0.4^{eB}	1.30±0.2^{e}	7.0±0.5^{b}
	200	4.20±0.4^{dA}	3.80±1.2^{dB}	3.40±0.5^{dC}	2.60±0.8^{dD}	3.50±0.4^{d}	3.60±0.7^{dA}	3.00±0.7^{dB}	2.00±0.6^{dC}	3.00±0.7^{dB}	3.00±0.3^{d}	
	400	8.20±1.2^{cA}	7.00±1.0^{cB}	6.00±1.1^{cC}	5.00±0.7^{cD}	6.60±0.6^{c}	6.40±1.2^{cA}	5.80±0.6^{cB}	4.20±0.9^{cD}	5.80±0.6^{cB}	5.30±0.4^{c}	
	800	12.8±1.3^{bA}	12.0±1.2^{bB}	10.4±1.0^{bC}	9.80±0.9^{bD}	11.3±0.6^{b}	11.4±1.1^{bA}	10.6±0.9^{bB}	8.00±1.1^{bD}	10.6±0.9^{bB}	9.80±0.5^{b}	
	1600	23.8±0.6^{aA}	22.8±1.0^{aB}	20.0±0.7^{aC}	18.4±1.2^{aD}	21.3±0.6^{a}	22.2±0.7^{aA}	21.2±0.9^{aB}	18.6±1.2^{aC}	21.2±0.9^{aB}	20.1±0.6^{a}	
	Control	0.20±0.2^{fA}	0.40±0.2^{fA}	0.20±0.2^{fA}	0.40±0.2^{fA}	0.30±0.1^{f}	0.80±0.4^{fA}	0.80±0.4^{eA}	0.40±0.2^{eB}	0.80±0.4^{eA}	0.60±0.2^{f}	
	Mean	8.50±1.5^{A}	7.90±1.5^{B}	6.90±1.3^{C}	6.20±1.2^{D}	7.4±0.7	7.60±1.4^{A}	7.10±1.3^{B}	5.60±1.2^{D}	7.10±1.3^{B}	6.7±0.6	
C. petroselinum	100	1.60±0.2^{eBC}	2.0±0.3^{eAB}	1.4±0.4^{eC}	2.20±0.4^{eA}	1.80±0.2^{e}	1.80±0.2^{eA}	1.20±0.4^{eB}	1.80±0.2^{eA}	1.20±0.4^{eB}	1.60±0.2^{e}	8.1±0.5^{a}
	200	4.60±0.7^{dAB}	4.80±0.4^{dA}	3.60±0.5^{dC}	4.40±0.7^{dB}	4.40±0.3^{d}	4.20±0.7^{dA}	3.40±0.9^{dB}	3.20±0.6^{dB}	3.40±0.9^{dB}	3.50±0.3^{d}	
	400	8.00±1.1^{cB}	8.40±1.0^{cA}	7.00±0.9^{cD}	7.40±0.9^{cC}	7.70±0.5^{c}	7.60±0.9^{cA}	5.80±0.6^{cC}	6.20±0.9^{cB}	5.80±0.6^{cC}	6.30±0.4^{c}	
	800	15.0±0.9^{bA}	15.8±0.9^{bA}	13.0±1.0^{bB}	11.6±1.4^{bC}	13.9±0.6^{b}	14.0±1.2^{bA}	13.2±1.2^{bB}	10.6±1.6^{bC}	13.2±1.2^{bB}	12.0±0.7^{b}	
	1600	24.8±0.2^{aA}	24.0±0.2^{aA}	23.2±0.7^{aB}	22.0±1.5^{aC}	23.5±0.5^{a}	23.4±0.7^{aA}	22.5±0.9^{aB}	21.2±1.0^{aC}	22.6±0.9^{aB}	21.6±0.5^{a}	
	Control	0.20±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.20±0.2^{fA}	0.30±0.1^{f}	0.40±0.2^{fA}	0.20±0.2^{fA}	0.20±0.2^{fA}	0.20±0.2^{fA}	0.20±0.1^{f}	
	Mean	9.00±1.6^{B}	9.20±1.6^{A}	8.10±1.5^{C}	8.00±1.4^{C}	8.6±0.8	8.60±1.5^{A}	7.70±1.5^{B}	7.20±1.4^{C}	7.70±1.5^{B}	7.5±0.7	
Salvia officinalis	100	2.00±0.3^{eA}	1.60±0.2^{eB}	1.00±0.3^{eC}	0.60±0.4^{eD}	1.30±0.2^{e}	1.20±0.4^{eA}	1.40±0.4^{eA}	0.60±0.2^{eB}	1.20±0.4^{eA}	0.90±0.2^{e}	6.3±0.4^{c}
	200	4.60±0.5^{dA}	3.60±1.1^{dB}	2.60±0.8^{dC}	2.20±0.4^{dD}	3.30±0.4^{d}	3.80±0.4^{dA}	3.40±0.5^{dB}	1.40±0.7^{dD}	3.80±0.4^{dA}	2.60±0.3^{d}	
	400	8.60±1.0^{cA}	7.00±1.0^{cB}	5.00±0.7^{cC}	3.40±0.8^{cD}	6.00±0.6^{c}	6.00±1.1^{cA}	5.80±0.9^{cA}	3.80±0.6^{cB}	6.00±1.1^{cA}	4.60±0.5^{c}	
	800	13.4±1.6^{bA}	11.8±1.1^{bB}	9.80±0.9^{bC}	6.80±1.1^{bD}	10.5±0.8^{b}	10.8±0.7^{bA}	10.6±0.7^{bA}	8.00±1.0^{bB}	10.8±0.7^{bA}	9.00±0.6^{b}	
	1600	22.0±0.6^{aA}	21.8±1.0^{aB}	19.4±1.1^{aC}	16.2±0.8^{aD}	19.9±0.7^{a}	20.0±0.9^{aA}	19.0±0.9^{aB}	16.6±0.9^{aC}	20.0±0.9^{aA}	17.6±0.6^{a}	
	Control	0.20±0.2^{fA}	0.20±0.2^{fA}	0.40±0.2^{fA}	0.20±0.2^{eA}	0.30±0.1^{f}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{eA}	0.40±0.2^{fA}	0.40±0.1^{f}	
	Mean	8.50±1.4^{A}	7.70±1.4^{B}	6.40±1.3^{C}	4.90±1.1^{D}	6.9±0.6	7.00±1.3^{A}	6.80±1.2^{A}	5.10±1.1^{B}	7.00±1.3^{A}	5.8±0.6	
Mean of insect		7.86±0.4^{A}					6.94±0.3^{B}					
Mean of age		1 st instar		2 nd instar			3 rd instar		4 th instar			
		8.99±0.5^{A}		8.30±0.5^{B}			7.02±0.5^{C}		6.30±0.3^{D}			

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.
A, B & C: There is no significant difference (P>0.05) between any two means for the same attribute, within the same row have the same superscript letter.

Table 2: Larvicidal effect of different concentrations of *M. chamomilla*, *O. majorana*, *C. petroselinum* and *S. officinalis* against of *A. caspius* and *C. pipiens* larvae after 48 hours.

Plant oils	Conc. (ppm)	Mosquito larvae										Mean of oil
		A. caspius					*C. pipiens*					
		1 st instar	2 nd instar	3 rd instar	4 th instar	1 st instar	1 st instar	2 nd instar	3 rd instar	4 th instar	Mean	
Matricaria chamomilla	100	5.60±1.1^{eA}	4.60±0.7^{eB}	3.20±0.4^{eD}	3.60±0.8^{eC}	4.30±0.4^{e}	5.60±0.5^{eA}	4.40±0.9^{eB}	3.00±0.4^{eC}	2.20±0.4^{eD}	3.80±0.4^{e}	10.5±0.5^{a}
	200	8.60±1.1^{dA}	7.00±0.8^{dB}	6.40±1.2^{dC}	6.20±0.9^{dD}	7.10±0.5^{d}	8.80±0.7^{dA}	8.40±1.1^{dB}	5.60±0.7^{dC}	5.80±1.0^{dC}	7.20±0.5^{d}	
	400	12.6±0.9^{cA}	10.2±0.9^{cC}	10.6±0.7^{cB}	9.20±1.2^{cD}	10.7±0.5^{c}	11.8±0.6^{cA}	12.0±1.2^{cA}	8.80±0.9^{cB}	8.20±0.9^{cC}	10.2±0.6^{c}	
	800	19.2±1.6^{bA}	18.2±1.2^{bB}	16.0±0.5 ^{bC}	13.8±1.5^{bD}	16.8±0.8^{b}	20.2±1.4^{bA}	16.6±0.7^{bB}	16.2±1.1^{bC}	13.0±1.1^{bD}	16.5±0.8^{b}	
	1600	25.0±0.0^{aA}	25.0±0.0^{aA}	24.4±0.6^{aC}	22.8±1.0^{aD}	24.3±0.3^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	24.4±0.4^{aB}	21.4±1.4^{aC}	24.0±0.5^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.20±0.2^{fA}	0.40±0.1^{f}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.20±0.2^{fA}	0.40±0.1^{f}	
	Mean	11.9±1.6^{A}	10.9±1.6^{B}	10.2±1.5^{C}	9.30±1.4^{D}	10.6±0.8	12.0±1.6^{A}	11.1±1.5^{B}	9.70±1.6^{C}	8.50±1.4^{D}	10.3±0.8	
Origanum majorana	100	5.00±0.4^{eA}	3.80±0.4^{eB}	2.80±0.6^{eD}	3.20±0.7^{eC}	3.70±0.3^{e}	4.20±0.6^{eA}	3.2±0.7^{eB}	2.40±0.2^{eC}	2.00±0.3^{eD}	3.00±0.3^{e}	9.3±0.5^{c}
	200	7.60±0.7^{dA}	6.00±0.5^{dB}	5.00±0.7^{dD}	5.40±0.9^{dC}	6.00±0.4^{d}	7.80±0.7^{dA}	6.80±0.9^{dB}	5.40±0.9^{dC}	5.00±0.8^{dD}	6.30±0.5^{d}	
	400	11.8±1.5^{cA}	9.20±1.2^{cB}	8.80±0.9^{cC}	8.20±1.0^{cD}	9.50±0.6^{c}	9.80±0.7^{cA}	9.40±0.7^{cB}	8.20±0.9^{cC}	6.60±0.5^{cD}	8.50±0.4^{c}	
	800	16.4±0.7^{bA}	15.4±1.4^{bB}	12.8±0.6^{bD}	13.4±1.2^{bC}	14.5±0.6^{b}	16.0±1.3^{bA}	14.6±1.6^{bB}	11.8±1.1^{bC}	11.2±1.5^{bD}	13.4±0.8^{b}	
	1600	25.0±0.0^{aA}	24.8±0.2^{aA}	23.4±0.9^{aB}	21.2±1.0^{aC}	23.6±0.5^{a}	25.0±0.0^{aA}	24.4±0.4^{aB}	22.2±0.7^{aC}	20.0±0.9^{aD}	22.9±0.5^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	
	Mean	11.0±1.5^{B}	9.90±1.5^{B}	8.90±1.4^{C}	8.60±1.3^{C}	9.6±0.7	10.5±1.5^{A}	9.80±1.5^{B}	8.40±1.4^{C}	7.50±1.3^{D}	9.1±0.7	
Carum petroselinum	100	4.20±0.6^{eB}	5.80±1.0^{eA}	3.00±0.4^{eD}	3.80±0.6^{eC}	4.20±0.4^{e}	3.8±0.8^{eA}	3.40±0.6^{eB}	3.80±0.6^{eA}	3.00±0.5^{eC}	3.50±0.3^{e}	10.1±0.5^{b}
	200	7.00±0.7^{dB}	7.80±1.0^{dA}	5.60±0.7^{dD}	6.60±0.5^{dC}	6.80±0.4^{d}	7.00±1.2^{dA}	6.40±1.0^{dB}	6.60±0.5^{dB}	5.00±0.7^{dC}	6.30±0.4^{d}	
	400	12.8±1.0^{cA}	11.2±1.1^{cB}	8.80±0.9^{cD}	10.2±0.8^{cC}	10.8±0.5^{c}	11.4±0.9^{cA}	10.2±0.9^{cB}	9.40±0.5^{cC}	7.80±1.1^{cD}	9.70±0.5^{c}	
	800	18.4±0.8^{bA}	16.6±1.5^{bB}	15.0±1.3^{bC}	13.4±1.8^{bD}	15.9±0.8^{b}	17.8±0.7^{bA}	14.0±1.1^{bC}	15.0±1.6^{bB}	12.4±1.4^{bD}	14.8±0.7^{b}	
	1600	25.0±0.0^{aA}	25.0±0.0^{aA}	24.8±0.2^{aA}	24.4±0.4^{aB}	24.8±0.1^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	23.6±0.7^{aB}	22.6±0.7^{aC}	24.1±0.3^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	
	Mean	11.3±1.6^{A}	11.10±1.5^{A}	9.60±1.6^{B}	9.80±1.5^{B}	10.5±0.8	10.9±1.6^{A}	9.90±1.5^{B}	9.80±1.5^{B}	8.50±1.4^{C}	9.8±0.7	
Salvia officinalis	100	3.80±0.4^{eB}	5.20±1.1^{eA}	3.40±0.7^{eC}	2.20±0.9^{eD}	3.70±0.4^{e}	4.60±0.7^{eA}	4.80±0.7^{eA}	2.20±0.2^{eB}	1.40±0.2^{eC}	3.30±0.4^{e}	9.1±0.5^{c}
	200	5.80±0.6^{dB}	7.60±0.7^{dA}	5.00±0.9^{dC}	4.20±0.9^{dD}	5.70±0.5^{d}	7.00±0.8^{dB}	7.40±0.9^{dA}	4.20±0.8^{dC}	3.40±0.5^{dD}	5.50±0.5^{d}	
	400	10.8±1.2^{cB}	12.0±1.4^{cA}	8.00±1.1^{cC}	6.60±1.0^{cD}	9.40±0.7^{c}	10.2±0.9^{cB}	10.8±1.0^{cA}	7.00±0.7^{cC}	6.20±0.6^{cD}	8.60±0.6^{c}	
	800	15.2±1.4^{bB}	18.4±1.0^{bA}	14.6±1.7^{bC}	9.60±1.3^{bD}	14.5±1.0^{b}	16.0±1.0^{bA}	16.2±0.7^{bA}	10.8±1.1^{bB}	8.60±0.7^{bC}	12.9±0.9^{b}	
	1600	24.8±0.2^{aA}	25.0±0.0^{aA}	23.8±1.0^{aB}	19.2±0.7^{aC}	23.2±0.6^{a}	24.2±0.5^{aB}	24.6±0.4^{aA}	19.8±1.2^{aC}	17.0±1.1^{aD}	21.4±0.8^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	0.60±0.4^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.50±0.1^{f}	
	Mean	10.10±1.5^{B}	11.40±1.6^{A}	9.20±1.5^{C}	7.00±1.2^{D}	9.5±0.7	10.40±1.5^{A}	10.70±1.5^{A}	7.40±1.2^{B}	6.20±1.1^{C}	8.7±0.7	
Mean of insect		10.02±0.4^{A}					9.45±0.4^{B}					
Mean of age		1 st instar		2 nd instar			3 rd instar		4 th instar			
		11.03±0.5^{A}		10.62±0.5^{B}			9.14±0.5^{C}		8.19±0.5^{D}			

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.
A, B & C: There is no significant difference (P>0.05) between any two means for the same attribute, within the same row have the same superscript letter.

Table 3: Larvicidal effect of different concentrations of *M. chamomilla*, *O. majorana*, *C. petroselinum* and *S. officinalis* against of *A. caspius* and *C. pipiens* larvae after 72 hours.

Plant oils	**Conc. (ppm)**	**Mosquito larvae**										**Mean of oil**
		A. caspius					***C. pipiens***					
		1 st instar	**2 nd instar**	**3 rd instar**	**4 th instar**	**Mean**	**1 st instar**	**2 nd instar**	**3 rd instar**	**4 th instar**	**Mean**	
Matricaria chamomilla	100	9.00±0.4^{eA}	7.60±1.0^{eB}	6.4±0.9^{eC}	6.80±0.9^{eC}	7.50±0.5^{e}	9.00±0.7^{eA}	8.40±1.8^{eB}	5.60±0.7^{eC}	4.60±0.2^{eD}	6.90±0.6^{e}	12.9±0.5^{a}
	200	11.6±0.8^{dA}	10.6±0.9^{dB}	9.6±1.2^{dC}	9.60±0.9^{dC}	10.4±0.5^{d}	12.2±1.0^{dA}	11.8±1.7^{dA}	8.40±0.9^{dB}	8.20±0.7^{dB}	10.2±0.7^{d}	
	400	16.4±1.6^{cA}	15.0±1.2^{cB}	14.2±1.3^{cC}	12.8±1.2^{cD}	14.6±0.7^{c}	16.4±1.2^{cA}	15.8±1.2^{cB}	12.8±1.5^{cC}	11.8±0.9^{cC}	14.2±0.7^{c}	
	800	22.6±0.8^{bA}	21.8±1.0^{bB}	20.4±1.0^{bC}	17.6±0.8^{bD}	20.6±0.6^{b}	24.0±0.3^{bA}	21.6±1.0^{bB}	19.8±1.1^{bC}	16.4±0.9^{bD}	20.5±0.8^{b}	
	1600	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	24.0±0.6^{aB}	24.8±0.2^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.4±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	0.40±0.2^{fA}	0.60±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.50±0.1^{f}	
	Mean	14.2±1.6^{A}	13.4±1.6^{B}	12.7±1.6^{C}	12.0±1.5^{D}	13.1±0.8	14.5±1.6^{A}	13.9±1.6^{B}	12.0±1.6^{C}	10.9±1.5^{D}	12.8±0.8	
Origanum majorana	100	7.80±1.1^{eA}	6.20±0.7^{eB}	6.4±0.8^{eB}	5.20±1.1^{eC}	6.40±0.5^{e}	6.60±0.9^{eA}	6.40±0.8^{eA}	5.40±0.5^{eB}	3.80±0.7^{eC}	5.60±0.4^{e}	11.8±0.5^{b}
	200	9.80±1.1^{dA}	8.80±1.2^{dB}	8.4±0.8^{dB}	7.80±1.4^{dC}	8.70±0.6^{d}	9.60±1.4^{dA}	10.0±0.9^{dA}	8.00±0.9^{dB}	7.40±0.7^{dC}	8.80±0.5^{d}	
	400	14.4±1.0^{cA}	13.6±1.2^{cB}	12.4±1.5^{cC}	11.0±1.8^{cD}	12.9±0.7^{c}	13.8±1.1^{cA}	13.8±1.1^{cA}	12.0±1.4^{cB}	9.00±1.3^{cC}	12.2±0.7^{c}	
	800	21.0±0.6^{bA}	19.4±1.2^{bB}	18.6±1.2^{bC}	17.4±1.1^{bD}	19.1±0.6^{b}	21.2±0.7^{bA}	19.4±0.9^{bB}	17.0±0.7^{bC}	15.0±1.1^{bD}	18.2±0.7^{b}	
	1600	25.0±0.0^{aA}	24.6±0.2^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	24.9±0.1^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	23.2±0.9^{aA}	24.6±0.3^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.4±0.2^{fA}	0.60±0.2^{fA}	0.50±0.1^{f}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.40±0.1^{f}	
	Mean	13.1±1.6^{A}	12.2±1.5^{B}	11.9±1.5^{C}	11.20±1.6^{D}	12.1±0.8	12.8±1.6^{A}	12.5±1.5^{A}	11.3±1.5^{B}	9.80±1.4^{C}	11.6±0.8	
Carum petroselinum	100	8.6±0.7^{eA}	8.00±1.1^{eB}	6.6±0.8^{eC}	6.00±1.1eD	7.30±0.5^{e}	8.00±0.8^{eA}	7.40±1.2^{eB}	6.00±0.7^{eC}	5.40±0.5^{eD}	6.70±0.5^{e}	12.8±0.5^{a}
	200	11.2±1.1^{dA}	10.0±0.8^{dB}	9.2±0.7^{dC}	8.6±0.9dD	9.80±0.5^{d}	11.0±0.7^{dA}	10.6±0.7^{dA}	8.8±1.2^{dB}	8.20±1.0^{dC}	9.70±0.5^{d}	
	400	16.6±1.6^{cA}	14.8±1.9^{cB}	14.2±1.2^{cC}	11.6±1.2cD	14.3±0.8^{c}	14.8±1.4^{cA}	14.0±1.5^{cB}	12.8±1.2^{cC}	11.4±0.9^{cD}	13.3±0.7^{c}	
	800	22.8±0.9^{bA}	22.6±0.8^{bA}	19.4±0.9^{bB}	18.8±0.7bC	20.9±0.6^{b}	22.0±0.9^{bA}	20.8±0.7^{bB}	19.8±1.1^{bC}	16.8±0.9^{bD}	19.9±0.6^{b}	
	1600	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0aA	25.0±0.0^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	24.6±0.4^{aA}	24.9±0.1^{a}	
	Control	0.40±0.2^{fA}	0.40±0.2^{fA}	0.4±0.2^{fA}	0.60±0.2fA	0.50±0.1^{f}	0.40±0.2^{fA}	0.60±0.2^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.50±0.1^{f}	
	Mean	14.1±1.6^{A}	13.5±1.6^{B}	12.5±1.5^{C}	11.8±1.5D	13.0±0.8	13.5±1.6^{A}	13.1±1.5^{B}	12.1±1.6^{C}	11.1±1.5^{D}	12.5±0.8	
Salvia officinalis	100	7.0±0.8^{eB}	8.60±1.1^{eA}	5.2±1.1^{eC}	4.60±0.8^{eD}	6.40±0.6^{e}	7.00±1.0^{eB}	7.80±1.1^{eA}	5.40±0.5^{eC}	3.40±0.7^{eD}	5.90±0.6^{e}	11.6±0.5^{b}
	200	9.20±1.2^{dB}	11.6±1.2^{dA}	7.8±1.4^{dC}	6.60±1.0^{dD}	8.80±0.7^{d}	9.80±0.7^{dB}	10.8±1.0^{dA}	7.20±0.9^{dC}	5.20±0.4^{dD}	8.30±0.6^{d}	
	400	14.0±0.9^{cB}	16.0±1.5^{cA}	11.6±1.5^{cC}	10.0±1.0^{cD}	12.9±0.8^{c}	14.2±1.6^{cB}	15.2±1.2^{cA}	11.2±1.5^{cC}	8.40±1.0^{cD}	12.3±0.9^{c}	
	800	19.6±1.4^{bB}	22.4±0.7^{bA}	17.6±1.2^{bC}	12.6±1.0^{bD}	18.1±1.0^{b}	21.2±0.8^{bA}	21.2±0.7^{bA}	15.8±0.9^{bB}	12.0±0.7^{bC}	17.6±1.0^{b}	
	1600	25.0±0.0^{aA}	25.0±0.0^{aA}	25.0±0.0^{aA}	22.0±1.3^{aA}	24.2±0.4^{a}	25.0±0.0^{aA}	25.0±0.0^{aA}	22.4±0.7^{aB}	21.0±1.2^{aC}	23.4±0.5^{a}	
	Control	0.60±0.2^{fA}	0.60±0.2^{fA}	0.4±0.2^{fA}	0.40±0.2^{fA}	0.50±0.1^{f}	0.60±0.4^{fA}	0.40±0.2^{fA}	0.40±0.2^{fA}	0.60±0.2^{fA}	0.50±0.1^{f}	
	Mean	12.6±1.5^{B}	14.0±1.6^{A}	11.3±1.6^{C}	9.40±1.3^{D}	11.8±0.8	13.0±1.6^{A}	13.4±1.6^{A}	10.4±1.4^{B}	8.40±1.3^{C}	11.3±0.7	
Mean of insect		12.47±0.4^{A}					12.04±0.4^{B}					
Mean of age		1 st instar		2 nd instar			3 rd instar		4 th instar			
		13.45±0.6^{A}		13.24+0.5^{A}			11.68±0.5^{B}		10.66±0.5^{C}			

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.
A, B & C: There is no significant difference (P>0.05) between any two means for the same attribute, within the same row have the same superscript letter.

Table 4: Relative efficiency of the tested plant oils against all larval instars of *A. caspius* and *C. pipiens* at different time intervals post-treatment.

Period (h)	Oil	Age	*A. caspius*				*C. pipiens*			
			LC_{50}	Slope	P value	LC_{90}	LC_{50}	Slope	P value	LC_{90}
24	*M. chamomilla*	1 st	514	2.732	0.200	1513	532	2.530	0.265	1708
		2 nd	560	2.757	0.193	1632	720	2.354	0.407	2521
		3 rd	669	2.249	0.355	1899	616	2.386	0.439	2121
		4 th	723	1.957	0.452	3268	851	1.906	0.739	4000
	O. majorana	1 st	565	2.301	0.204	20.37	720	2.481	0.436	2366
		2 nd	649	2.343	0.335	2289	800	2.512	0.586	2589
		3 rd	808	1.981	0.573	3583	1027	2.423	0.673	3471
		4 th	952	2.143	0.855	3772	980	1.772	0.472	5184
	C. troselinum	1 st	508	2.624	0.188	1565	574	2.413	0.414	1950
		2 nd	523	2.374	0.526	1813	651	2.484	0.464	2136
		3 rd	623	2.515	0.409	2013	750	2.083	0.363	3091
		4 th	649	1.997	0.341	2846	875	1.854	0.608	4297
	S. officinalis	1 st	677	2.178	0.497	2624	865	1.991	0.799	3808
		2 nd	587	2.075	0.678	2434	802	2.096	0.664	3281
		3 rd	901	2.250	0.725	3344	1160	2.367	0.954	4037
		4 th	1267	2.024	0.650	5446	1727	2.025	0.747	6128
48	*M. chamomilla*	1 st	310	2.093	0.301	1270	316	1.991	0.456	1389
		2 nd	373	2.000	0.154	1427	359	2.054	0.194	1511
		3 rd	430	2.211	0.329	1634	463	2.312	0.242	1658
		4 th	505	1.831	0.359	2531	599	1.876	0.609	2885
	O. majorana	1 st	365	2.007	0.153	1587	400	2.062	0.100	1676
		2 nd	446	2.167	0.102	1742	461	2.104	0.156	1872
		3 rd	558	2.054	0.253	2346	616	1.941	0.320	2818
		4 th	594	1.807	0.583	3038	755	1.821	0.564	3819
	C. petroselinum	1 st	389	1.856	0.915	1908	375	2.292	0.290	1360
		2 nd	356	1.912	0.108	1667	451	2.138	0.074	1795
		3 rd	623	1.965	0.902	2079	597	1.949	0.249	2714
		4 th	463	1.635	0.093	3787	464	1.955	0.298	2101
	S. officinalis	1 st	431	2.166	0.135	1684	419	1.979	0.228	1859
		2 nd	339	2.122	0.242	1360	388	1.975	0.181	1729
		3 rd	514	2.125	0.171	2062	779	1.812	0.624	3970
		4 th	863	1.722	0.513	4785	1063	1.724	0.778	5883
72	*M. chamomilla*	1 st	197	2.019	0.460	850	188	2.184	0.293	727
		2 nd	232	2.071	0.420	963	213	1.893	0.636	1011
		3 rd	278	1.844	0.856	1376	315	1.977	0.639	1401
		4 th	297	1.806	0.178	1521	376	1.897	0.413	1780
	O. majorana	1 st	255	1.779	0.705	1337	280	1.716	0.733	1561
		2 nd	293	1.988	0.467	1294	275	1.974	0.388	1226
		3 rd	723	1.957	0.452	3268	346	1.980	0.173	1537
		4 th	363	2.055	0.154	1525	467	1.863	0.318	2277
	C. petroselinum	1 st	204	1.863	0.510	994	228	1.786	0.657	1192
		2 nd	229	2.126	0.269	918	259	1.713	0.762	1450
		3 rd	323	2.024	0.183	1387	297	2.080	0.343	1227
		4 th	277	1.989	0.394	1221	357	1.905	0.210	1679
	S. officinalis	1 st	279	1.923	0.440	1292	275	1.644	0.732	1656
		2 nd	207	2.036	0.465	882	237	1.634	0.875	1444
		3 rd	349	2.051	0.191	1470	417	1.641	0.615	2521
		4 th	524	1.576	0.325	3411	650	1.725	0.484	3593

Table 5: Relative efficiency of the tested plant oils against pupal stage of *A. caspius* and *C. pipiens* at different time intervals post-treatment.

Period (h)	Oil No.	*A. caspius*				*C. pipiens*			
		LC_{50}	Slope	P value	LC_{90}	LC_{50}	Slope	P value	LC_{90}
24	*M. chamomilla*	1221	1.865	0.934	5944	1246	2.018	0.907	5377
	O. majorana	780	1.735	0.630	4271	848	1.691	0.597	4857
	C. petroselinum	640	1.688	0.636	3675	1179	1.565	0.680	7773
	S. officinalis	1478	1.809	0.974	7556	1380	2.006	0.956	6010
48	*M. chamomilla*	922	1.559	0.605	6120	900	1.779	0.785	4730
	O. majorana	666	1.590	0.510	4264	576	1.619	0.672	3566
	C. petroselinum	482	1.669	0.209	2825	723	1.757	0.813	3875
	S. officinalis	1061	1.565	0.683	6992	967	1.800	0.830	4984
72	*M. chamomilla*	647	1.590	0.648	4141	610	1.699	0.797	3463
	O. majorana	462	1.701	0.284	2621	354	1.689	0.247	2032

	C. petroselinum	330	1.844	0.139	1634	534	1.646	0.634	3209
	S. officinalis	727	1.559	0.758	4823	682	1.692	0.823	3900

Table 6: The effect of plant oils; *M. chamomilla, O. majorana, C. petroselinum* and *S. officinalis* on duration, pupal rate and adult emergence of *A. caspius* and *C. pipiens* after treatment of 1st larval instar**.**

Oil	Conc. (ppm)	*A. caspius*				*C. pipiens*			
		Duration (days)		Percent pupation	Percent Adult Emergence	Duration (days)		Percent pupation	Percent Adult Emergence
		Larval	Pupal			Larval	Pupal		
M. chamomilla	control	9	2	92	92	8	2	84	84
	100	17	6	52	40	23	7	72	56
	200	15	6	48	36	19	6	60	44
	400	10	4	20	8	13	4	32	20
	800	8	3	8	0	8	3	20	8
	1600	0	0	0	0	0	0	0	0
O. majorana	control	8	2	96	96	8	2	96	96
	100	15	5	72	64	20	5	80	72
	200	13	5	64	48	17	5	68	56
	400	10	3	40	28	11	3	40	28
	800	7	3	32	16	7	3	32	16
	1600	0	0	0	0	0	0	0	0
C. petroselinum	control	8	2	84	84	9	2	88	88
	100	19	8	52	36	24	9	64	48
	200	17	7	44	28	19	7	56	36
	400	12	5	20	8	15	5	20	12
	800	8	3	4	0	8	4	12	0
	1600	0	0	0	0	0	0	0	0
S. officinalis	control	9	2	96	96	9	2	88	88
	100	14	5	72	44	15	5	72	44
	200	12	4	64	36	14	4	64	36
	400	9	3	48	24	9	3	48	24
	800	7	3	24	8	7	3	24	8
	1600	0	0	0	0	0	0	0	0

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