INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY ISSN: 2456-6683 Volume - 5, Issue - 10, Oct - 2021
Monthly Peer-Reviewed, Refereed, Indexed Journal Scientific Journal Impact Factor: 5.743
Received on : 15/10/2021 Accepted on : 30/10/2021 Publication Date: 31/10/2021

LARVICIDAL ACTIVITY OF PLANT OIL, LAVENDULA LATIFOLIA AGAINST THE SELECTED MOSQUITO LARVAE AND GC-MS ANALYSIS OF ITS PHYTOCHEMICAL COMPOUNDS

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Abstract: *In the current time, global attention for the control of vectors has moved from chemical insecticides to botanicals. In the present investigation, authors attempted to evaluate the bio efficacy of plant oil, Lavendula latifolia with special reference to its larvicidal activity with different concentrations against the larvae of Aedes aegypti, Anopheles stephensi and Culex quinquefasciatus. Larvicidal activity and phytochemical compounds of L. latifolia elicited its possible role in combat with the larvae of Ae. aegypti, An. stephensi and C. quinquefasciatus. Further studies regarding the application of such oil in the field will pave the way for development of new green mosquitocide in the future.*

Key Words: *Plant oil, Larvicidal activity, GC-MS analysis, Lavendula latifolia, Ae. aegypti, An. stephensi and C. quinquefasciatus*

1. INTRODUCTION:

Mosquitoes are the vectors of the major infectious diseases of public health concern such as Malaria, Dengue, Lymphatic filariasis, Yellow fever, Chikungunya and Zika virus causing morbidity and mortality in tropical and subtropical Africa. WHO has declared the mosquitoes as "public enemy number one". Mosquito borne diseases are prevalent in more than 100 countries across the world, infecting over 700,000,000 people per annum and four crores of Indian population.

Mosquito control is considered as essential to prevent the spreading of mosquito borne diseases and to improve quality of sustainable environment and the health status of publics. Earlier, synthetic mosquitocides such as organochlorine and organophosphate compounds were used as the major tool in mosquito control operation but, this has not been completely successful due to human, technical, operational, economical and ecological factors. The present practice of using synthetic chemical insecticides to control mosquito vectors have result in the development of serious resistance, persistent pollution and damaging the ecosystem.

In past few decades, the indiscriminate application of several synthetic insecticides in mosquito control programme has been banned or limited. It is due to lack of novelty, high cost, concern for environmental sustainability, harmful effect on human health, and other non-target creatures, prolonged persistence in nature, higher rate of biological magnification through ecosystem, and increasing insecticide resistance on a global scale. These factors have resulted in an urge to look for environment friendly, cost-effective, biodegradable and target specific insecticides against mosquito species. Considering these, the application of eco-friendly alternatives such as biological control of vectors has become the central focus of the control programme in lieu of the chemical insecticides.

Recently, essential oils have emerged as potential renewable, cost-effective, and environmentally benign alternatives to synthetic pesticides for control of mosquitoes. Exploration of plants and plant based secondary metabolites are one of the positive approaches under the biological control programme in mosquito control. Furthermore, unlike conventional insecticides which are based on a single active ingredient, insecticides from plant's origin comprised of spectrum of chemical compounds which act concertedly in many processes by disturbing the insect's physiology or morphology. Hence, there is very little chance of developing resistance to such substances by the mosquitoes. Identifying bio-insecticides that are efficient, as well as being suitable and adaptive to ecological conditions, is imperative for continued effective vector control management. Botanicals have broad spectrum of insecticidal properties and will obviously work as a new armament in the future may act as suitable alternative product in combating the mosquitoes. Hence, in the present investigation, the larvicidal activity of *Lavendula latifolia* was investigated on the fourth instar larvae of *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*.

2. MATERIALS AND METHODS:

Preparation of the oil for the bioassay

Plant oil, *Lavendula latifolia* was purchased from the distributor. 0.50mg, 0.100mg, 0.150mg, 0.200mg and 250mg oil was weighed and mixed with 250ml of double distilled water to obtain 200ppm, 400ppm, 600ppm, 800ppm

and 1000ppm concentrations respectively with this 0.05ml of dimethyl sulphoxide (DMSO) was used as an emulsifier to blend the oil with water.

Larvicidal bioassay

The larvicidal activities of the selected oil at various concentrations were carried out according to the method prescribed by the World Health Organization (WHO, 2005). Fourth instar larvae of *Ae. aegypti*, *An. stephensi and C. quinquefasciatus* were used in the present study. Twenty larvae were placed in a paper cup with 250 ml of aqueous suspension of tested material at various concentrations, and an emulsifier dimethyl sulfoxide (DMSO) was added in the final test solution (0.05%). Five replicates per concentration were run simultaneously and with each experiment, a set of controls using 0.05 % DMSO and acetone and untreated sets of larvae in distilled water, were also run for comparison. The assay was carried out in laboratory and the larval mortality was recorded after 24 h of exposure.

Statistical analysis

Percentage mortality was corrected for control mortality using Abbott's formula [Abbotts, 1925]. Results from all replicates for the oil were subjected to probit analysis using SPSS (v20.0) to determine LC50and LC90values and their 95 % confidence intervals [Sakuma, 1998]. Samples for which the 95 % fiducial limits did not overlap were considered to be significantly different.

3. ANALYSIS AND RESULT:

The larvicidal activity of *L. latifolia* was tested against the third instar larvae of *Ae. Aegypti, An. stephensi and C. quinquefasciatus* with 200, 400, 600, 800 and 1000 ppm concentrations. The data pertaining to the experiment are shown in table 1 and figures 1 to 3. It was observed that 17.8±1.4, 35.2±1.4. 63.6±2.4, 74.8±2.6 and 94.2±3.0% larval mortality at 200, 400, 600, 800 and 1000 ppm concentrations respectively against the larvae of *Ae. aegypti*. Similarly, 18.8±1.6, 37.6±1.8. 63.2±2.2, 74.4± 2.8 and 93.8±3.2% larval mortality at 200, 400, 600, 800 and 1000 ppm concentrations respectively against the larvae of *An. stephensi*. Likewise, 17.4±1.2, 33.4±2.4, 62.4±2.6, 73.6±3.2 and 93.2±3.6% larval mortality at 200, 400, 600, 800 and 1000 ppm concentrations respectively against the larvae of *C. quinquefasciatus*. Moreover, the LC_{50} value of 517.13ppm was recorded with the LCL and UCL values of 472.32 and 559.33ppm respectively against the larvae of *Ae. aegypti*. In the same way, the LC_{90} value of 951.60ppm was recorded with the LCL and UCL values of 883.73 and 1041.47ppm respectively against the larvae of, *Ae. aegypti*. The LC_{50} value of 510.36ppm was recorded with the LCL and UCL values of 463.68 and 553.93ppm respectively was noted against the larvae of *An. stephensi*. In the same way, the LC_{90} value of 961.97ppm was recorded with the LCL and UCL values of 891.18 and 1056ppm respectively against the larvae of *An. stephensi*. The LC_{50} value of 529.79 was recorded with the LCL and UCL values of 484.90 and 572.35ppm respectively was noted against the larvae of *C. quinquefasciatus*. In the same way, the LC_{90} value of 970.47ppm was recorded with the LCL and UCL values of 900.78 and 1063.03ppm respectively against the larvae of *C. quinquefasciatus*. At the same time, the probit responses showed by the *L. latifolia* oil tested on the fourth instar larvae of *Ae. aegypti*, *An. stephensi* and *C. quinquefasciatus* were showed positive responses to the concentrations tested in the present experiment and the respective figures are shown in figures 4-6.

The phytochemical constituents of the selected oil was analyzed with GC-MS (Make: PerkinElmer Clarus 500, Column Type: Capillary Column Elite-5ms (5%Phenyl 95% dimethylpolysiloxane). Column length: 30m, Column id: 250µm, Oven Program: 60ºC@3 ºC/min to 240 ºC. Injector temp. : 280ºC, Carrier gas: He @ 1ml/min. Split ratio: 1:20, Mass Range: 40-450amu. Library: NIST 2005). GC-MS analysis of L.latifolia oil, showed presence of 47 phytochemical compounds of which peak 15, and peak 18 were identified as major compounds such as 1,6-Octadien-3-ol, 3,7-dimethyl and 1-Cyclohexyl-2-buten-1-ol respectively (Figures 5.97 & 5.98; Table 5.13) and remaining other compounds were identified as minor compounds. Phytochemical compounds present in the selected oil are as follows: 6-Methyl-hept-2-en-4-ol; (S)-3-Ethyl-4-methylpentanol; 3-Hexen-1-ol; Hexanol; Bicyclo[3.1.0]hex-2-ene, 2-methyl-5-(1-methylethyl)-; 1S-à-Pinene; Camphene; Cyclohexene, 4-methylene-1-(1methylethyl)-; Bicyclo[3.1.1]heptane, 6,6dimethyl-2-methylene-, 1S)-; 3-Heptanone, 5-methyl-; Eucalyptol; 1,3,6-Octatriene, 3,7-dimethyl-, (E)- ; 1,3,6-Octatriene, 3,7-dimethyl-, (E)-; 2-Furanmethanol, 5-ethenyltetrahydro-à,à,5-trimethyl-, cis-; 1,6-Octadien-3-ol, 3,7-dimethyl; Bicyclo[2.2.1]heptan-2-one, 1,7,7trimethyl-, (1S)-; 3-Cyclohexen-1-ol, 4-methyl-1-(1methylethyl)-; 1-Cyclohexyl-2-buten-1-ol (c,t); 2,6-Octadien-1-ol, 3,7-dimethyl-, acetate; Bicyclo[3.1.1]heptane-2methanol, 6,6-dimethyl-, acetate; 2,6-Octadien-1-ol, 3,7-dimethyl-, acetate, (E)-; Benzenemethanol, 4-(1methylethyl)-; Cyclobutanecarboxylic acid, hexyl ester; 2,7-Octadiene-1,6-diol, 2,6dimethyl-; Epoxy-à-terpenyl acetate; 2,6-Octadien-1-ol, 3,7-dimethyl-, acetate, (E)-; 2,6-Octadien-1-ol, 3,7-dimethyl-, acetate; Caryophyllene; Bicyclo[3.1.1]hept-2-ene, 2,6dimethyl-6-(4-methyl-3-pentenyl)-; Bicyclo[7.2.0]undec-4-ene, 4,11,11-trimethyl-8-methylene-,[1R(1R*,4Z,9S*)]-; 1,6,10-Dodecatriene, 7,11dimethyl-3-methylene-, (E)-; 1H-Cyclopenta[1,3] cyclopropa[1,2]benzen e, octahydro-7-methyl-3-methylene-4-(1methylethyl)-, [3aS(3aà,3bá,4á,7à,7aS*)]-; Cyclohexene, 1-methyl-4-(5methyl-1-methylene-4-hexenyl)-, (S)-; Naphthalene, 1,2,3,4,4a,5,6,8aoctahydro-7-methyl-4-methylene-1-(1methylethyl)-, (1à,4aà,8aà)- ; .tau.-Muurolol; Kauren-18-ol, acetate, (4á)-; Isoaromadendrene epoxide; 5,9,13-Pentadecatrien-2-one, 6,10,14-trimethyl-, (E,E)-;

1,6,10-Dodecatrien-3-ol, 3,7,11trimethyl-, (E)-; 2,6,11,15-Tetramethyl-hexadeca2,6,8,10,14-pentaene; Caryophyllene oxide; à-Bisabolol; 1-Naphthalenol, 1,2,3,4,4a,7,8,8aoctahydro-1,6-dimethyl-4-(1methylethyl)-, [1R-(1à,4á,4aá,8aá)]-; tau.-Cadinol; Caryophyllene oxide; Benzyl Benzoate and 2-Pentadecanone, 6,10,14trimethyl.

Table 1. Larvicidal activity of *Lavendula latifolia* oil tested against the freshly moulted (0-6h old) fourth instar larvae of selected mosquito species.

Concentration (ppm)	Mortality* (%)	LC_{50} (LCL - UCL)	LC_{90} (LCL - UCL)	χ^2
Aedes aegypti				
Control	1.8±0.8[a]	517.13 (472.32-559.33)	951.60 (883.73-1041.47)	2.790
200	17.8±1.4[b]			
400	35.2±1.4[c]			
600	63.6±2.4[d]			
800	74.8±2.6[e]			
1000	94.2±3.0[f]			
Anopheles stephensi				
Control	1.8±0.2 [a]	510.36 (463.68 - 553.93)	961.97 (891.18- 1056.54)	2.523
200	18.8±1.6 [b]			
400	37.6±1.8 [c]			
600	63.2±2.2 [d]			
800	74.4± 2.8 [e]			
1000	93.8±3.2 [f]			
Culex quinquefasciatus				
Control	1.6±0.8 [a]	529.79 (484.90 - 572.35)	970.47 (900.78- 1063.03)	2.702
200	17.4±1.2[b]			
400	33.4±2.4[c]			
600	62.4±2.6[d]			
800	73.6±3.2[e]			
1000	93.2±3.6[f]			

Values expressed mean ± SD of five replications. Values with different alphabets in the column differs statistically (DMRT,p<0.005)

Figure 1. Larvicidal activity of *L.latifolia* tested against the larvae of *Aedes aegypti*.

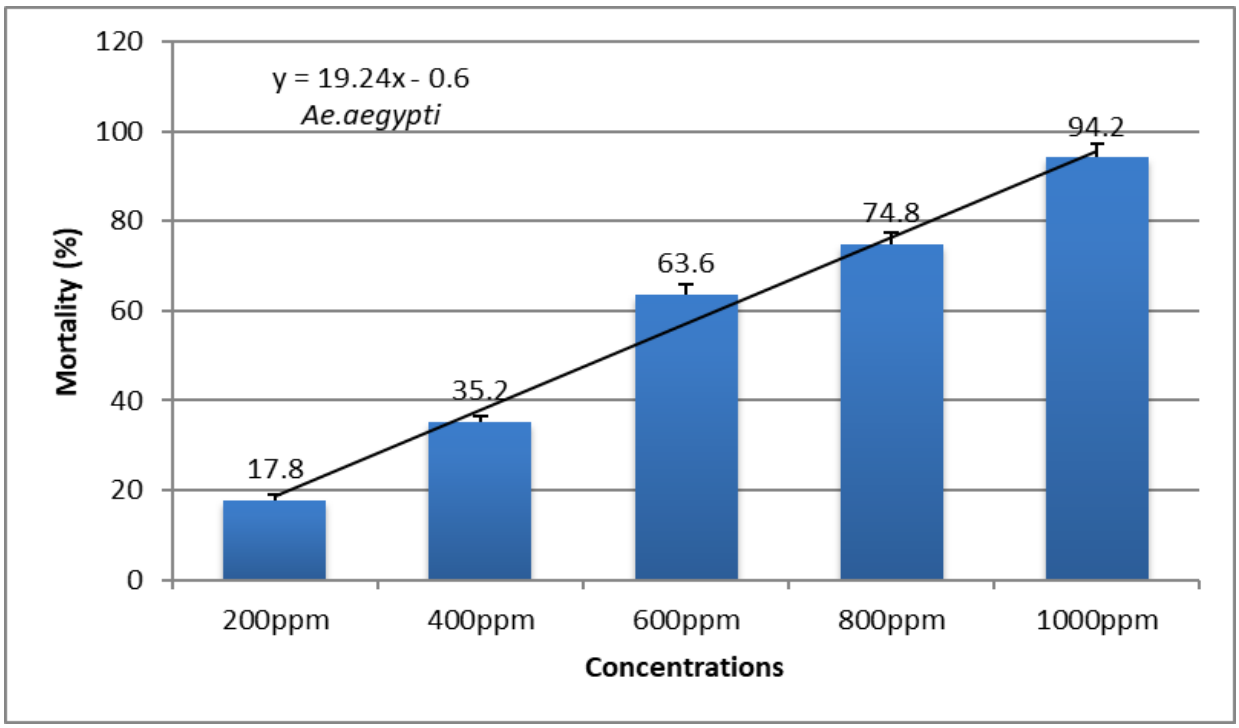


Figure 2. Larvicidal activity of *L.latifolia* tested against larvae of *Anopheles stephensi.*

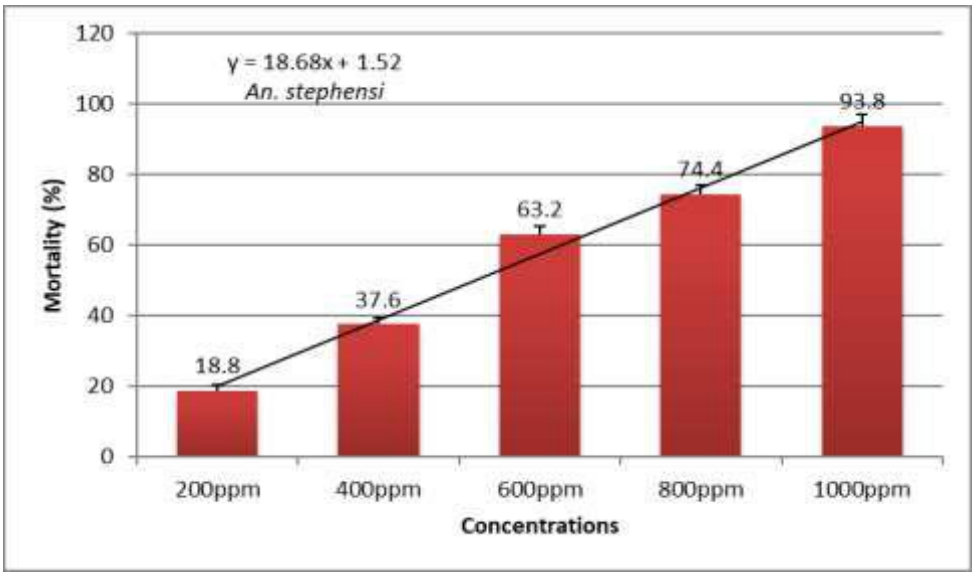


Figure 3. Larvicidal activity of *L.latifolia* tested against the larvae of *Culex quinquefasciatus*

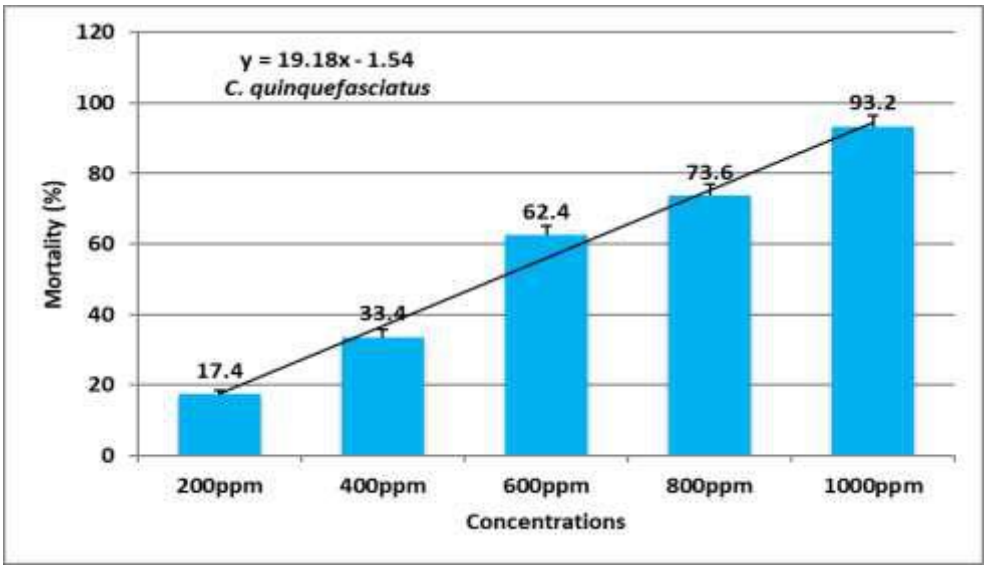


Figure 4. Probit transformed responses observed on *O L.latifolia* tested against the *Aedes aegypti* larvae.

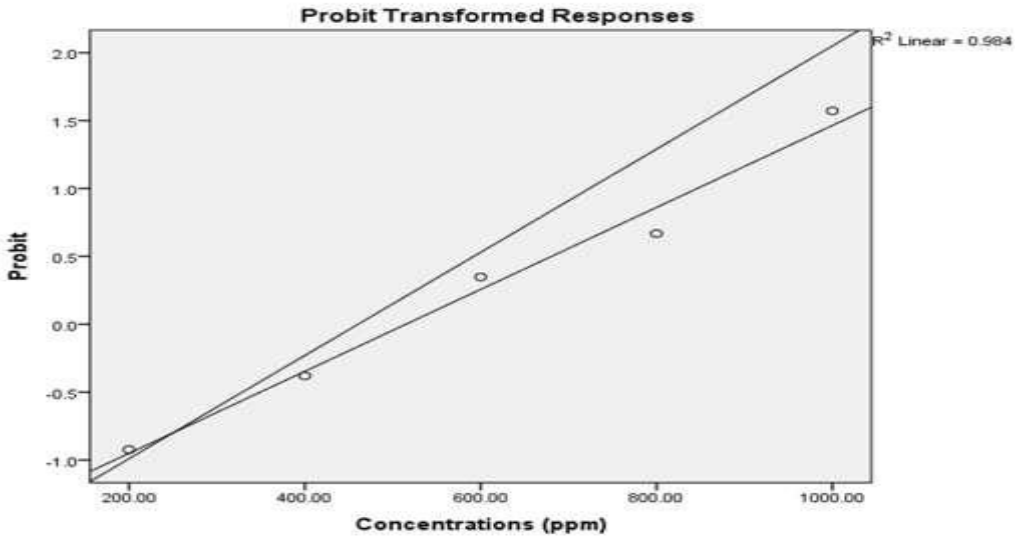


Figure 5. Probit transformed responses observed on *L.latifolia* tested against the *Anopheles stephensi* larvae.

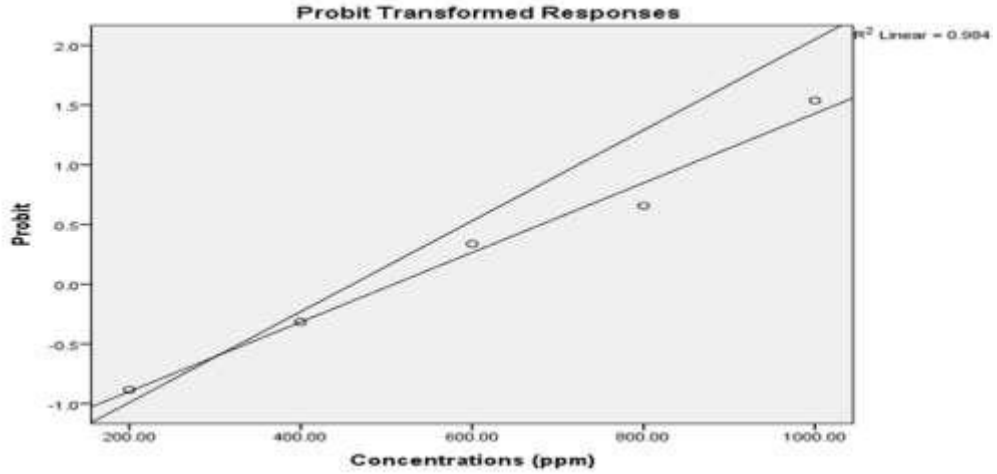


Figure 6. Probit transformed responses observed on *L.latifolia* tested against the *Culex quinquefasciatus* larvae.

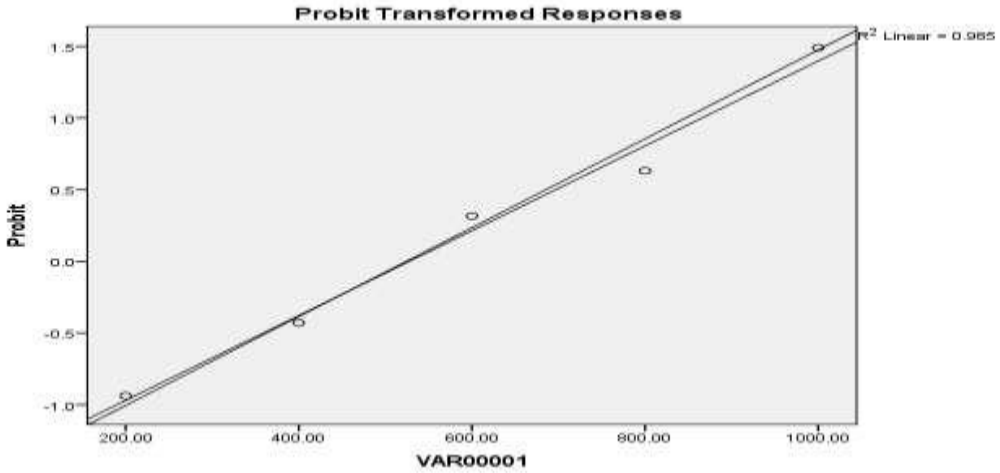
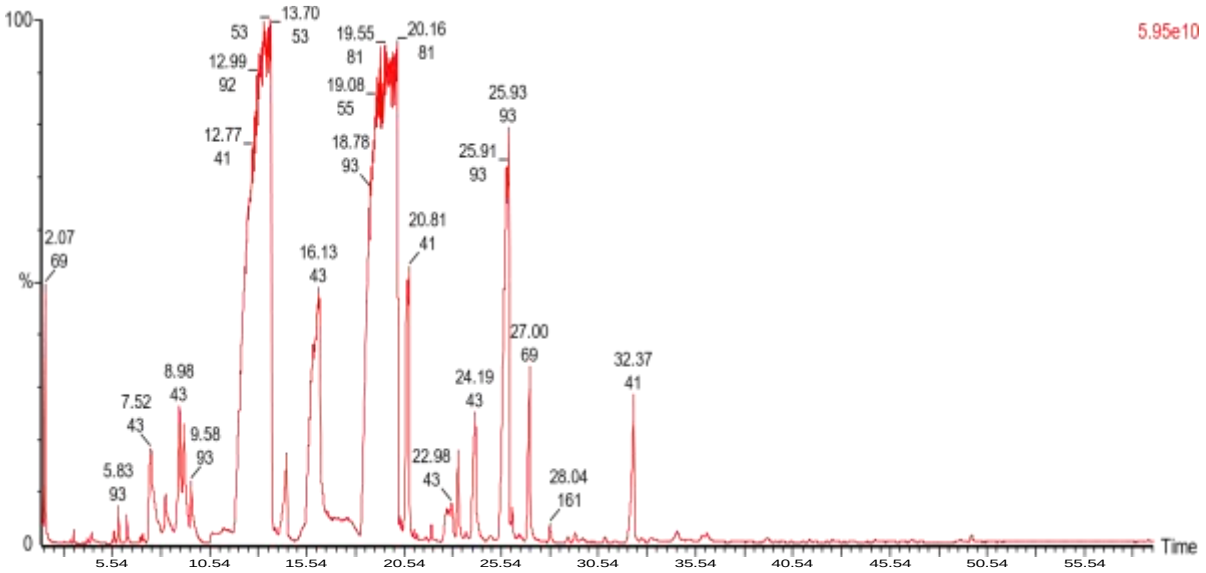


Table 2. List of phytochemical compounds identified from the *Lavendula latifolia* oil by Gas Chromatography coupled with Mass Spectroscopy (GC-MS).

S.No.	Peak Name	Retention time	%Peak area	Mol. Wt	Formula
1.	6-Methyl-hept-2-en-4-ol	1.73	0.2020	128	$C_8H_{16}O$
2.	(S)-3-Ethyl-4-methylpentanol	2.07	0.4838	130	$C_8H_{18}O$
3.	3-Hexen-1-ol	4.23	0.0185	100	$C_6H_{12}O$
4.	Hexanol	4.46	0.0293	102	$C_6H_{14}O$
5.	Bicyclo[3.1.0]hex-2-ene, 2-methyl-5-(1-methylethyl)-	5.63	0.0364	136	$C_{10}H_{16}$
6.	1S-à-Pinene	5.83	0.1210	136	$C_{10}H_{16}$
7.	Camphene	6.27	0.0989	136	$C_{10}H_{16}$
8.	Cyclohexene, 4-methylene-1-(1methylethyl)-	6.98	0.0181	136	$C_{10}H_{16}$
9.	Bicyclo[3.1.1]heptane, 6,6dimethyl-2-methylene-, 1S)-	7.09	0.0379	136	$C_{10}H_{16}$
10.	3-Heptanone, 5-methyl-	7.52	1.3906	128	$C_8H_{16}O$
11.	Eucalyptol	8.98	0.8920	154	$C_{10}H_{18}O$
12.	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	9.20	0.8131	136	$C_{10}H_{16}$
13.	1,3,6-Octatriene, 3,7-dimethyl-, (E)-	9.58	0.2516	136	$C_{10}H_{16}$
14.	2-Furanmethanol, 5-ethenyltetrahydro-à,à,5-trimethyl-, cis-	10.68	0.0444	170	$C_{10}H_{18}O_2$
15.	1,6-Octadien-3-ol, 3,7-dimethyl	12.99	34.4992	154	$C_{10}H_{18}O$
16.	Bicyclo[2.2.1]heptan-2-one, 1,7,7trimethyl-, (1S)-	14.48	0.8549	152	$C_{10}H_{16}O$

17.	3-Cyclohexen-1-ol, 4-methyl-1-(1methylethyl)-	16.13	7.6427	154	$C_{10}H_{18}O$
18.	1-Cyclohexyl-2-buten-1-ol (c,t)	20.16	38.0339	154	$C_{10}H_{18}O$
19.	2,6-Octadien-1-ol, 3,7-dimethyl-, acetate	20.68	1.3035	196	$C_{12}H_{20}O_2$
20.	Bicyclo[3.1.1]heptane-2methanol, 6,6-dimethyl-, acetate	20.81	1.3593	196	$C_{12}H_{20}O_2$
21.	2,6-Octadien-1-ol, 3,7-dimethyl-, acetate, (E)-	21.05	0.0187	196	$C_{12}H_{20}O_2$
22.	Benzenemethanol, 4-(1methylethyl)-	21.19	0.0158	150	$C_{10}H_{14}O$
23.	Cyclobutanecarboxylic acid, hexyl ester	21.94	0.0649	184	$C_{11}H_{20}O_2$
24.	2,7-Octadiene-1,6-diol, 2,6dimethyl-	22.75	0.4345	170	$C_{10}H_{18}O_2$
25.	Epoxy-à-terpenyl acetate	22.98	0.2875	212	$C_{12}H_{20}O_3$
26.	2,6-Octadien-1-ol, 3,7-dimethyl-, acetate, (E)-	23.33	0.5140	196	$C_{12}H_{20}O_2$
27.	2,6-Octadien-1-ol, 3,7-dimethyl-, acetate	24.19	1.0596	196	$C_{12}H_{20}O_2$
28.	Caryophyllene	25.93	6.1480	204	$C_{15}H_{24}$
29.	Bicyclo[3.1.1]hept-2-ene, 2,6dimethyl-6-(4-methyl-3-pentenyl)-	26.10	0.0669	204	$C_{15}H_{24}$
30.	Bicyclo[7.2.0]undec-4-ene, 4,11,11-trimethyl-8-methylene-,[1R(1R*,4Z,9S*)]-	26.47	0.0072	204	$C_{15}H_{24}$
31.	1,6,10-Dodecatriene, 7,11dimethyl-3-methylene-, (E)-	27.00	1.2744	204	$C_{15}H_{24}$
32.	1H-Cyclopenta[1,3]cyclopropa[1,2]benzen e, octahydro-7-methyl-3-methylene-4-(1methylethyl)-, [3aS(3aà,3bá,4á,7à,7aS*)]-	28.04	0.1162	204	$C_{15}H_{24}$
33.	Cyclohexene, 1-methyl-4-(5methyl-1-methylene-4-hexenyl)-, (S)-	28.97	0.0438	204	$C_{15}H_{24}$
34.	Naphthalene, 1,2,3,4,4a,5,6,8aoctahydro-7-methyl-4-methylene-1-(1methylethyl)-, (1à,4aà,8aà)-	29.35	0.0755	204	$C_{15}H_{24}$
35.	.tau.-Muurolol	29.73	0.0595	222	$C_{15}H_{26}O$
36.	Kauren-18-ol, acetate, (4á)-	30.87	0.0509	330	$C_{22}H_{34}O_2$
37.	Caryophyllene oxide	32.37	1.2911	220	$C_{15}H_{24}O$
38.	à-Bisabolol	33.20	0.0430	222	$C_{15}H_{26}O$
39.	1-Naphthalenol, 1,2,3,4,4a,7,8,8aoctahydro-1,6-dimethyl-4-(1methylethyl)-, [1R-(1à,4á,4aá,8aá)]-	33.51	0.0220	222	$C_{15}H_{26}O$
40.	tau.-Cadinol	34.60	0.0460	222	$C_{15}H_{26}O$
41.	Caryophyllene oxide	35.90	0.0642	220	$C_{15}H_{24}O$
42.	Benzyl Benzoate	39.23	0.0459	212	$C_{14}H_{12}O_2$
43.	2-Pentadecanone, 6,10,14trimethyl-	41.39	0.0136	268	$C_{18}H_{36}O$
44.	Isoaromadendrene epoxide	45.75	0.0094	220	$C_{15}H_{24}O$
45.	5,9,13-Pentadecatrien-2-one, 6,10,14-trimethyl-, (E,E)-	49.17	0.0342	262	$C_{18}H_{30}O$
46.	1,6,10-Dodecatrien-3-ol, 3,7,11trimethyl-, (E)-	49.74	0.0502	222	$C_{15}H_{26}O$
47.	2,6,11,15-Tetramethyl-hexadeca2,6,8,10,14-pentaene	58.84	0.0119	272	$C_{20}H_{32}$

Figure 7. GC-MS chromatogram of plant oil *L.latifolia.*



4. DISCUSSION:

In the present investigation *L. latifolia* oil showed statistically significant activity against the fourth instar larvae of *Ae. aegypti, An. Stephensi* and *C. quinquefasciatus*. Among the three larvae, *C. quinquefasciatus*. is more susceptible than *Ae. aegypti* and *An. stephensi* . The larval mortality observed in the present experiment is due to the fact that the presence of 35 phytochemicals in the *L. latifolia* (Table 2; Figure 7) could be responsible for the larval mortality in the present experimentation. Furthermore, while conducting the experiment the application of oil with the respective concentration formed a thin film over the surface of the experimental cups, suggesting that the oil film could prevent the further exchange of gases in to the medium of experimental cups thereby causing death of the larvae by asphyxia. In more recent publications, it was also noted that the plant oils have promising insecticidal activity, compared to the results of the few, observed that larvicidal activity was more higher in this study for mosquitoes than that reported earlier. The high level of larvicidal activity of the *L. latifolia* is possibly due to the higher concentration of the major compounds present in it. Our present findings are go in hand in hand with the earlier findings of several authors.

To quote few, Hung *et al.* (2020) leaf essential oils of Callicarpa species like *C. bodinieri, C. candicans, C. formosana, C. longifolia, C. nudiflora, C. petelotii, C. rubella,* and *C. sinuata,* from central Vietnam were screened for larvicidal activity of *Ae. Aegypti* and found that All of the Callicarpa leaf essential oils showed larvicidal activity and *Callicarpa candicans* essential oil should be considered as a potential alternative mosquito control agent. Manh *et al.* (2020) showed the larvicidal activity of essential oils extracted from *Cymbopogon citratus, Cymbopogon winterianus, Eucalyptus citriodora,* and *Eucalyptus camaldulensis* aromatic plants grown in Vietnam was tested on *Ae. aegypti* larvae and found to be the most efficient against *Ae. aegypti.*

The larvicide based on Food grade orange oil encapsulated in yeast was shown to be highly active against all larval stages of *Ae. aegypti.* These findings demonstrated its potential for incorporation in an integrated approach to larval source management of *Ae. aegypti.* This novel approach can enable development of affordable control strategies that may have significant impact on global health. (Workman *et al.*, 2020)

Aksorn Chantawee and Mayura Soonwera (2020), evaluated larvicidal, pupicidal and oviposition deterrent activities of four plant essential oils from *Alpinia galanga* (L.) Willd rhizome, *Anethum graveolens* L. fruit, *Foeniculum vulgare* Mill. fruit, and *Pimpinella anisum* L. fruit against *Ae. aegypti*. and showed that *A. graveolens* oil has a good potential as a larvicidal, pupicidal and oviposition deterrent agent for controlling *Ae. aegypti.*

Xu *et al.* (2019) in a study of bioassay on essential oil which is extracted from the leaf of *Cinnamomum camphora* (L.) against *A. stephensi* showed that the essential oil of *C. camphora* leaf has an excellent larvicidal potential for the control of *A. stephensi*. Sowmyashree *et al.* (2019) observed that the larvae of *An. stephensi.* were highly susceptible to the essential oils of *Psidium guajava* than *Aegle marmelos* and could consequently be used to reduce the prevalence of malaria in the endemic areas. Scalvenzi *et al.* (2019) screened the potential larvicidal effect of essential oils extracted from *Ocimum campechianum, Ocotea quixos* and *Piper aduncum* were tested against *Ae. aegypti* and GC and GC–MS analyses were made to isolate the active compounds. The result showed that rapid and effective larvicidal activity of these three oils against *Ae. aegypti.* Sofian *et al.* (2019) investigated the larvicidal activity of ethanol extract

and essential oil from Zingiber aromaticum Val. rhizome against *Ae. aegypti* larvae and was observed that the extract and isolated essential oil from *Z. aromaticum* possessed remarkable larvicidal properties.

Dalia *et al.* (2019) showed the larvicidal potentiality and ultra structural changes induced in mosquitoes of *Culex pipiens* L. by the actions of three plant oil extracts of *Piper nigrum*, *Eucalyptus regnans* and *Azadirachta indica* oil and elucidated that a dramatic changes were observed in the midgut of mosquito larvae treated with *Piper nigrum*; that could serve as a potential larvicidal agent. Hung *et al.* (2019) analysed the effect of essential oils of two weedy species in Vietnam, *Erechtites hieraciifolius* and *E. valerianifolius*, by gas chromatography–mass spectrometry and have been screened for mosquito larvicidal activity against *Aedes albopictus*, *Ae. aegypti*, and *C. quinquefasciatus* and showed *Erechtites* essential oils may serve as low-cost vector control agents for mosquito-borne infections.

Huong *et al.* (2019) thirteen species of Piper were collected from different areas of central Vietnam and essential oils were obtained by hydrodistillation were analyzed by gas chromatography–mass spectrometry were screened for mosquito larvicidal activity against *Aedes aegypti*. Four of the *Piper* essential oils showed outstanding larvicidal activity against *Ae. aegypti*, namely *P. caninum*, *P. longum*, *P. montium*, and *P. mutabile*.

Kasim *et al.* (2019) in a study demonstrated the potency of garlic (*Allium sativum*) in managing the larvae and thus contributes as an affordable way to control anopheles and culex larvae of mosquitoes. Kaura *et al.* (2019), showed that *Eucalyptus* oil was more effective against mosquito larvae at lower concentration as compared to neem oil. It can, therefore, be utilized in the community in artificial and small temporary water bodies as an eco-friendly vector control measure in the era of increasing resistance to chemical insecticides.

Martianasari, R and Hamid, PH (2019), demonstrated clearly that essential oil derived from *Piper betle* L. potentially acts as alternate bioinsecticide to control *Ae. aegypti* population. The application can be varied or combined in different stages of mosquito development. Wondmeneh *et al.* (2019) demonstrate the strong mosquitocidal potential of *Lepidium sativum*, and *Millettia ferruginea* essential oils against *Anopheles gambiae sensu lato.* However, further formulation and field evaluation are important for large scale field application to control the population of *An. gambiae.* Navaneetha Pandiyan *et al.* (2019) extracted essential oils from *Syzygium aromaticum* flower buds, fruits of *Illicium verum and Trachyspermum ammi* by hydro-distillation and tested against *Ae. Aegypti* larvae individually and in combinations to find synergistic interactions and showed attention to the capability of synergistic EO combinations to emerge as a safe and environment friendly effective larvicide to control Aedes mosquitoes. Riju sarma *et al.* (2019) twenty-eight combinations of plant essential oil-based terpene compounds were prepared and tested against larval and adult stages of *A. aegypti* and the result revealed that , the combination of Temephos and Diallyldisulfde and combination of Malathion and Eudesmol were the most efective combination. These effective combinations bear potential prospect to be used against *A. aegypti.*

5. CONCLUSIO:

Indiscriminate application of chemical pesticides in general mosquitocides in particular cause an imbalance in the environment as well as to the human health also. Thus, scientific community world-wide started to search for new and novel alternative chemicals of plant origin. In this context, application of plant oil to control the mosquito larvae proven to be the best strategy in integrated vector control program. As, a part of it, the present investigation of larvicidal activity of *L.latifolia* elicited its possible role in combat with the larvae of *Ae. aegypti*, *An. stephensi* and *C. quinquefasciatus*. Further studies regarding the application of such oil in the field will pave the way for development of new green mosquitocide in the future.

6. ACKNOWLEDGEMENT:

Author is thankful to the Head, Department of Zoology and The Principal, Govt. Arts College for Men (Autonomous), Nandanam, Chennai for providing the laboratory facilities. Authors also thanks the authorities of Sastra University, Thanjavur, Tamilnadu for GC-MS analysis.

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