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Phytochemical analysis of *Malvastrum coromandelianum* and *Mimusops elengi:* Mosquitocidal properties of their leaf extract against dengue vector, *Aedes aegypti* (L.)

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Abstract

Mosquitoes are responsible for the intolerable biting nuisance and the transmission of a large number of diseases, such as malaria, yellow fever, dengue, filariasis, chikungunya. Many studies on plant extracts against mosquito larvae have been conducted around the world. The present study were conducted in order to determine the phytochemical analysis, larval and pupal toxicity, ovicidal activity of *Malvastrum coromandelianum* and *Mimusops elengi* methanolic leaf extract against the dengue vector, *Aedes aegypti*. Phytochemical analysis of *M. coromandelianum* methanolic leaf extract revealed the presence of alkaloids, flavonoids, phenols, tannins, proteins, carbohydrates, steroids, triterpenoids and *M. elengi* leaf extract contains alkaloids, flavonoids, phenols, carbohydrates, steroids, triterpenoids and saponins. GC/MS analysis identified at least 25 bioactive compounds in the *M. coromandelianum* methanolic leaf extract and 10 bioactive compounds in *M. elengi* methanolic leaf extract. In mosquitocidal bio-assay, LC_{50} of *M. coromandelianum* leaf methanol extract against *Aedes aegypti* larvae and pupae were 378.59 ppm (larva I), 404.42 ppm (II), 415.35 ppm (III), 486.01 ppm (IV), and 509.59 ppm (pupa). LC_{50} of *M. elengi* were 345.31 ppm (I), 389.62 ppm (II), 417.41 ppm (III), 467.33 ppm (IV), and 499.17 ppm (pupa). In ovicidal assay, egg hatchability was reduced by 100% after treatment with 400 ppm of *M. coromandelianum* and *M. elengi*. Overall, our results highlighted that *M. coromandelianum* and *M. elengi* could be useful candidates to develop bio-formulated mosquitocidal effective against dengue vector, *Ae. Aegypti.*

Keywords: *Malvastrum coromandelianum, Mimusops elengi,* GC/MS study, *Aedes aegypti,* larvicide

Introduction

Mosquitoes are important vectors of aggressive pathogens and bloodsuckers, which may hit as pandemics or epidemics in the accelerating world populations of humans and animals [1, 2, 3]. Emergence and re-emergence of contagious diseases is a major public health concern worldwide. Presently Zika virus, an Aedes mosquito- borne flavivirus, is a new arboviral hazard, exhibiting suspected association with over 4000 recent cases of microcephaly among newborn babies in Brazil [4, 5]. Most of these dengue vector species are common in natural and artificial containers such as gutters, pools, septic tanks, tree holes, leaf axils, fruit peels, discarded tires, water jars, old boats and others [6]. The number of dengue cases reported by WHO increased over 8 fold over the last two decades, from 505,430 cases in 2000, to over 2.4 million in 2010, and 5.2 million in 2019. Reported deaths between the year 2000 and 2015 increased from 960 to 4032, affecting mostly the younger age groups. The total number of cases seemingly decreased during years 2020 and 2021, as well as for reported deaths. However, the data is not yet complete and COVID-19 pandemic might have also hampered case reporting in several countries. With the introduction of organic insecticides in the 1940s, chemical control became the most popular approach for controlling mosquitoes [7]. Long term exposure to the chemical insecticides will lead to selecting mutation, conferring a level of resistance to chemical insecticides and indeed the insecticide-resistance population of mosquitoes [8]. Biological products such as plant extracts offer boundless possibilities for a new phytochemical discovery due to the higher availability of a vast range of chemicals and environmental friendly approach as compared to synthetic insecticides [9]. Furthermore, many plant extracts rich in antioxidants have been reported as effective against different species of mosquito vectors, acting as ovicides [10], larvicides, and pupicides [11, 12] [13], adulticides [14], oviposition deterrents [15], growth and/or reproduction inhibitors, and/or adult repellents [16]. Antioxidant phytochemicals protect our cells from damage caused by free radicals. Among them, alkaloids, saponins, anthraquinones, tannins, and flavonoids are important scavengers, acting as antioxidants against free radicals [17, 18, 19]. The antioxidant activity is important in malaria treatment since oxidative stress normally follows malaria infection. This is due to elevated production of reactive oxygen species [20]. *Malvastrum coromandelianum* (L.) Garcke (family *Malvaceae*), commonly known as false mallow, broom weed, and clock plant. Various parts of this plant are used by numerous tribal populations throughout the world. Mexican Kickapoo Indians use the crushed leaves of this herb along with salt or alcohol to cure ringworm infection [21]. Bhil tribes of Rajasthan use this plant in the form of decoction to cure jaundice [22]. In Mexico, leaf

infusion of this plant is used to cure diabetes [23]. In traditional Indian system of medicine, this plant reports anti-inflammatory, analgesic, and antidysenteric properties [24, 25, 26]. Pharmacological screening showed various activities for this plant like antinociceptive [27], anti-inflammatory, and analgesic activity [28] and antimicrobial activity [29, 30, 31]. *Mimusops elengi* (an evergreen tree of 30 feet tall, with a greyish brown fissured bark, wavy and dull green leaves, oblong berry fruit and creamy fragrant flowers) an Indian native plant used for a long time in the history of the medicine is a member of family Sapotaceae distributed in tropical and subtropical regions [32, 33, 34]. This plant is well studied because of its high potential medicinal value and is known to possess various phytochemicals such as gallic acid esters, flavones, triterpenoids and steroids. The volatile constituents of the flowers have also been reported [35]. *M. elengi* is well documented for several medicinal properties like antino-ciceptive, diuretic effects, gastro-protective, antibacterial, antifungal, anti-carcinogenic, free radical scavenging, antihyper-glycemic etc. Due to this since several decades it is being focused for its chemical composition [36]. These phytochemicals may also have a mosquitocidal potential. Concerning other insect pests, *Momordica charantia* demonstrated toxicity against *Ae. aegypti* larvae, thus confirming the efficacy of this species has a source of active natural plant products and its importance as a potential new larvicide for controlling the mosquito vector of dengue virus, zika, chikungunya, and urban yellow fever [37]. In the present research work, we investigated the preliminary phytochemical analysis of leaf methanolic extracts of *M. coromandelianum* and *M. elengi* and evaluated the bioactive compounds using Gas chromatography–mass spectrometry (GC-MS). Furthermore we investigated the larval and pupal toxicity and ovicidal activity of methanolic leaf extract of *M. coromandelianum* and *M. elengi* against the dengue vector, *Ae. aegypti.*

Materials and methods

Collection and Preparation of Plant Extracts

M. coromandelianum and *M. elengi* leaves were collected from Tamil Nadu Agricultural University (TNAU), Coimbatore. The freshly collected leaves were thoroughly washed in running tap water and rinsed in distilled water before cutting into small bits, then shade-dried at room temperature for 10 days, powdered using laboratory blender and preserved in 1000 mL air tight bottle. The dried powdered leaves of each plant were extracted with methanol using soxhlet apparatus. After effective extraction solvents were concentrated using rotary vacuum evaporator under reduced pressure. The crude extracts were weighed and its percentage yield was recorded. One gram of the plant residue was dissolved in 100 mL of acetone (fixative agent to separate the aqueous impurities altering the chemical composition of plant crude extract) and considered as 1 % stock solution. From this stock solution, experimental concentrations were prepared.

Preliminary studies on phytochemical screening

The qualitative phytochemical screening of *M. coromandelianum* and *M. elengi* extracts standard procedures were followed to trace out the presence of active biomolecules i.e. Alkaloids, Saponins, Flavonoids, Steroids, Terpenoids, Tannins, Phenols, Carbohydrates and Proteins by Harborne (1973) [38], Trease and Evans (1989) [39] and Sofowara (1993) [40].

Gas chromatography-mass spectrometry (GC–MS) analysis

GC–MS analyses of *M. coromandelianum* and *M. elengi* leaf extracts was carried out using the Perkin-Elmer Clarus 680 system (Perkin-Elmer, Inc. U.S.A) equipped with a fused silica column, packed with Elite-5MS) capillary column (30 m in length×250 µm in diameter×0.25 µm in thickness). Pure helium gas (99.99%) was used as the carrier gas at a constant flow rate of 1 mL/min. For GC– MS spectral detection, an electron ionization energy method was adopted with high ionization energy of 70 eV (electron Volts) with 0.2 s of scan time and fragments ranging from 40 to 600 m/z. The injection quantity of 1 µL was used (split ratio 10:1), and the injector temperature was maintained at 250 °C (constant). The column oven temperature was set at 50 °C for 3 min, raised at 10 °C per min up to 280 °C, and final temperature was increased to 300 °C for 10 min. Te contents of phytochemicals present in the test samples were identified based on comparison of their retention time (min), peak area, peak height and mass spectral patterns with those spectral database.

Aedes aegypti mosquito rearing

Eggs of *A. aegypti* were provided by the National Centre for Disease Control (NCDC) field station of Mettupalayam (Tamil Nadu, India). Eggs were transferred to laboratory conditions [27 ± 2 °C, 75–85% R.H., 14:10(L/D) photoperiod] and placed in 18 × 13 × 4-cm plastic containers containing 500 ml of tap water for hatching. Larvae were fed daily with a mixture of dog biscuits (Pedigree, USA) and hydrolyzed yeast (Sigma-Aldrich, Germany) at 3:1 (w/w) ratio. Larvae and pupae were collected, transferred to glass beakers filled with 500 ml of dechlorinated water, and tested in subsequent experiments [41].

Larvicidal and pupicidal toxicity in laboratory conditions

Twenty-five *A. aegypti* larvae (I, II, III, or IV instars) or pupae were placed for 24 h in a glass beaker filled with 250 ml of dechlorinated water plus the desired concentration of *M. coromandelianum* and *M. elengi* methanolic leaf extract separately (100, 200, 300, 400, and 500 ppm). Larval food (0.5 mg) was provided for each tested concentration [42]. Each concentration was replicated five times against all instars.

Control mosquitoes were exposed for 24 h to the corresponding concentration of the solvent. Percentage mortality was calculated as follows:

Percentage mortality = (number of dead individuals / number of treated individuals) × 100

Ovicidal activity

Following Su and Mulla (1998) [43], in ovicidal activity experiments, *A. aegypti* eggs were collected placing ovitraps (i.e. Petri dishes, diameter 60 mm, lined with filter paper and containing 100 ml of water) inside each cage. Ovitraps were stored in the cages for 2 days from the blood meal of females. The eggs laid on filter paper lining were examined using a photomicroscope (Leica ES2, Germany). Then, the eggs were placed in a cage with six glass cups (diameter: 6 cm). Five of them were filled with water plus the *M. coromandelianum* and *M. elengi* methanol extract doses as follows: 100, 150, 200, 250 and 300 ppm (extract). The control cup was filled with distilled water. 100 eggs were placed in each cup. Five replicates were done for each dosage. After treatment, the eggs from each concentration were transferred to distilled water cups for hatching assessment after counting the eggs under microscope. The percent egg mortality was calculated on the basis of non-hatchability of eggs with unopened opercula [44]. The hatch rates were assessed 48 h post-treatment using the following formula [41]:

Egg mortality % = (number of hatched larvae / total number of eggs) × 100

Data analysis

SPSS software package 16.0 version was used for all analyses. Mosquito toxicity data from laboratory assays and bacteria inhibition growth data were transformed into arcsine/proportion values and then analyzed using a two-way ANOVA with two factors (i.e., dosage and mosquito instar). Means were separated by Tukey's HSD test. Furthermore, mosquito mortality data from laboratory assays were analyzed by probit analysis, calculating LC_{50} and LC_{90} following the method by Finney (1971). Ovicidal data were transformed into arcsine √proportion values and analyzed by ANOVA with two factors (i.e. dose and species). Means were separated using Tukey's HSD test ($P < 0.05$).

Results and Discussion

Phytochemical screening of *M. coromandelianum* and *M. elengi*

The methanolic leaf extracted was subjected to various chemical tests for the detection of secondary plant metabolites. The results have revealed that the *M. coromandelianum* presence of medicinally active constituents such as alkaloids, flavonoids, phenols, tannins, proteins, carbohydrates, steroids, triterpenoids and *M. elengi* leaf extract contains alkaloids, flavonoids, phenols, carbohydrates, steroids, triterpenoids and saponins were reported from leaves (Table 1). Similarly, Kalaiselvi *et al.,* (2016) [45] reported the phytochemical screening was carried out the *M. elengi* to detect the active constituents such as alkaloids, flavonoids, terpenoids, steroids, tannins, saponins, phenols, carbohydrates, proteins and aminoacid, fixed oil and fat. Later on, Vadivelan *et al.,* (2021) [46] reported the preliminary phytochemical studies confirmed the presence of alkaloid, carbohydrate, glycoside, protein, tannin, flavonoid, triterpenoid and phenol. Saxena and Rao, (2018) [47] highlighted the bioactive phytoconstituents categorized under steroids, alkaloids, phenols, fatty acids, flavonoids, vitamins and terpenes are presented the *M. coromandelianum* extract. Recently, Soundatti *et al.,* (2021) [48] reported that the phytochemicals analyses of *M. coromandelianum* leaf extract, the presence of alkaloids, carbohydrates, saponins, cardiac glycosides, steroids, tannins and proteins.

Gas chromatography-mass spectrometry (GC–MS) analysis of *M. coromandelianum* methanolic leaf extract

The GC–MS chromatogram of methanolic leaf extract of *M. coromandelianum* recorded a total of 25 peaks corresponding to the bioactive compounds that were recognized by relating their peak retention time, different peak areas (%) and mass spectral fragmentation patterns (Figure 1). Results of *M. coromandelianum* methanolic leaf extract identified 25 compounds (Table 2). The phytoconstituents in the methanolic leaf extract of *M. coromandelianum* were found to be sabinene, limonene, caryophyllene, naphthalene, ethyl vinyl carbinol, cedrene-V6, 1h-cyclopenta [1, 3] cyclopropa [1, 2] benzene, bicyclogermacrene, naphthalene, spathulenol, oxalic acid, ledol, 2-Hydrazinopyridine, bicyclo [3.1.1] heptanes, 2-Phthalic acid, isobutyl nonyl ester, phenanthrene, 7-Etheny, phytol, caryophyllene oxide, 1-Phenanthrenecarboxylic acid, propiophenone, ZINC561731, orthocresol, dimethyl{bis[(3-methylbut-2-en-1, squalene, 2,2,2-Trifluoroethyl methacrylate. Similarly, Konappa *et al.,* (2020) [49] have reported that GC–MS chromatogram of methanol and ethyl acetate leaf extracts of *A. nilgiricum* recorded a total of 15 peaks corresponding to the bioactive compounds that were recognized by relating their peak retention time, peak area (%), height (%) and mass spectral fragmentation patterns to that of the known compounds described by the National Institute of Standards and Technology (NIST) library. In earlier, Saxena and Rao (2018) [47] highlighted the GC-MS analysis of leaf extract of *M. coromandelianum* revealed that, a total of 29 bioactive compounds belonging to sterols, terpenes, phenols, vitamins, flavonoids, fatty acids, etc., and are presented with retention time, molecular weight, molecular formula and peak area in percentage.

Gas chromatography-mass spectrometry (GC–MS) analysis of *M. elengi* methanolic leaf extract

The GC–MS chromatogram of methanolic leaf extract of *M. elengi* recorded a total of 10 peaks corresponding to the bioactive compounds that were recognized by relating their peak retention time, different peak area (%) and mass spectral fragmentation patterns (Figure 2). Results of *M. elengi* methanolic leaf extract identified 10 compounds (Table 3). The phytochemical constituents in the methanolic leaf extract of *M. elengi* were found to be oxirane, (2, 2-dimethylpropyl)-. propanoic acid, 2-methyl-2-(3-pentadecylphenoxy)-,5-Eicosyne, Phthalic acid, inositol, stigmasterol, squalene, 2(1H) Naphthalenone 3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methylethenyl)-, 2,6,10,15,19,23-Hexamethyl-tetracosa-2,10,14,18,22-pentaene-6,7- diol and alpha-tochopherol. Similarly, Azhagumurugan and Rajan (2014) [50] detected nine compounds in the ethanolic extract of *Mimusops elengi* leaves. Among the identified phytochemicals, Stearic acid, 3-(octadecyloxy) propylester, Pregnane-3,11,12,14,20 – Phenol,3,12,20-triacetate, 11-(hydroxyacetate), (3a,11a,12a,14a), Hexadecanoic acid, methyl ester, 10-Octadecenoic acid, methyl ester and Squalene were antihelminthic and antibacterial, antifungal and anticancerous activity of the leaf extract. Thus, this type of GC-MS analysis is the first step towards understanding the nature of active principles in this medicinal plants and this type of study will be helpful for further detailed study.

Larval and pupal toxicity against dengue vector, *Ae. aegypti*

In laboratory conditions, the methanolic leaf extract of *M. coromandelianum* showed toxicity against larvae and pupae of *Ae. aegypti*. A dose-dependent effect was found, in agreement with previous evidences on other plant extracts [51, 52, 53]. The LC_{50} (LC_{90}) values of *M. coromandelianum* were 378.59 (814.28) ppm (larva I), 404.42 (845.51) ppm (II), 415.35 (909.57) ppm (III), 486.01 (980.57) ppm (IV), and 509.59 (999.14) ppm (pupa) (Table 4). The larvicidal activity of the *M. coromandelianum* leaf extract may be linked with the presence of the botanical compounds identified by GC/MS analysis, which primarily affect the midgut epithelium and secondarily affect the gastric ceaca and the malpighian tubules in mosquito larvae [54]. Previously, Yadav *et al.,* (2014) [55] highlighted the moderate larval mortality in *M. coromandelianum* and *A. scholaris* plant extracts. Nazar *et al.,* (2009) [56] has reported similar mortality rate in methanolic leaf extract of *M. coromandelianum* against *Cx. quinquefasciatus* larvae. Kaushik and Saini (2009) [57] while screening some plants for larvicidal activity against *Ae. aegypti*, found that acetone extract of *A. scholaris* showed its efficacy with the LC_{50} value of 239.9 ppm. The LC_{50} (LC_{90}) values of *M. elengi* were 345.31 (747.11) ppm (larva I), 389.62 (813.36) ppm (II), 417.41 (910.76) ppm (III), 467.33 (959.52) ppm (IV), and 499.17 (966.49) ppm (pupa) (Table 5). Rajkumar and Jebanesan (2008) [58] found that 0.01, 0.025, 0.05, 0.075 and 0.1 % ethanolic leaf extract of *Solanum trilobatum* reduced egg laying in *An. stephensi*, from 18–99% in treated containers. Many plants from different families possess promising phytochemicals for mosquito control which are much economical and environmental friendly Sivagnaname and Kalyanasundaram (2004) [59]. These phytochemicals like phenolics, alkaloids and terpenoids exist in plants extracts may jointly or independently contribute to the mosquitoes as larvicidal/oviposition deterrents/ repellents.

Ovicidal activity

In ovicidal experiments, egg hatchability of *Ae. aegypti* was reduced after treatment of *M.coromandelianum* and *M.elengi* extract exerted 100% mortality post-treatment with 400 ppm, while control eggs showed the 100% hatchability (Table 6). To the best of our knowledge, little efforts have been carried out to shed light on ovicidal properties of plant extracts. Similarly, Shehata *et al.,* (2020) [60] studied the hatchability of those eggs was subsequently reduced from 94.9% in the control to 59.4% and 34.8% at 25 and 50 ppm concentrations of *Pulicaria jaubertii* extract. Furthermore, the leaf extracts of *Cyathocline purpurea*, *Blumea lacera*, *Neanotis lancifolia*, and *Neanotis montholonii* have ovicidal activity. Extract of all the plants caused 70–90% mortality at higher concentrations Torawane *et al.,* (2021) [61]. Moreover, the ovicidal activity of methanolic root extract of *R. cordifolia* was the most potent compared to other with 82.40% and 70.40% activity against the eggs of *Cx. quinquefasciatus* and *Ae. aegypti*, at 500 mg/L, as reported by Munusamy *et al.,* (2016) [62].

Table 1: Phytochemical screening of *Malvastrum coromandelianum* and *Mimusops elengi* methanol extract

Phytochemicals	*M. coromandelianum*	*Mimusops elengi*
Alkaloids	+	++
Flavonoids	+	++
Phenols	+	++
Tannins	+	-
Saponin	-	+
Triterpenoids	+	+
Steroids	+	+
Proteins	++	++
Carbohydrates	++	++

Table 2: Chemical composition of *Malvastrum coromandelianum* methanol extract

S. No.	RT (min)	Name of the Compound	Molecular Formula	Molecular weight g/mol	Area %
1.	4.420	Sabinene	$C_{10}H_{16}$	136.23	1.33
2.	5.253	Limonene	$C_{10}H_{16}$	136.23	1.44
3.	10.486	Caryophyllene	$C_{15}H_{24}$	204.357	1.47
4.	10.597	Naphthalene	$C_{10}H_8$	128.1705	0.54
5.	10.753	Ethyl vinyl carbinol	$C_5H_{10}O$	86.13	0.51
6.	11.053	Cedrene-V6	$C_{15}H_{24}$	204.35	0.44
7.	11.153	1h-cyclopenta[1,3]cyclopropa[1,2]benzene	$C_{10}H_8$	128.17	3.20
8.	11.308	Bicyclogermacrene	$C_{15}H_{24}$	204.35	1.72
9.	11.508	Naphthalene	$C_{10}H_8$	128.1705	0.65
10.	12.164	Spathulenol	$C_{15}H_{24}O$	220.35	0.75
11.	12.530	Oxalic acid	$C_{18}H_{34}O_4$	314.5	1.53
12.	12.641	Ledol	$C_{15}H_{26}O$	222.37	1.39
13.	13.208	2-Hydrazinopyridine	$C_5H_7N_3$	109.13	0.46
14.	14.463	Bicyclo[3.1.1]heptane	$C_{10}H_{18}$	138.25	1.07
15.	15.508	2 Phthalic acid, isobutyl nonyl ester	$C_{21}H_{32}O_4$	348.5	0.69
16.	16.141	Phenanthrene, 7-ethenyl	$C_{20}H_{32}$	272.5	1.42
17.	16.707	Phytol	$C_{20}H_{40}O$	296.53	0.56
18.	18.107	Caryophyllene oxide	$C_{15}H_{24}O$	220.35	0.99
19.	18.429	1-Phenanthrenecarboxylic acid	$C_{15}H_{10}O_2$	222.24	29.44
20	19.185	Propiophenone	$C_9H_{10}O$	134.18	35.39
21	19.296	ZINC561731	$C_{15}H_{15}NOS$	257.4	5.04
22	19.952	Orthocresol	$CH_3C_6H_4$	108.14	0.47
23	20.785	Dimethyl {bis[(3-methylbut-2-en-1...	$C_{12}H_{24}O_2Si$	228.40	0.63
24	21.418	Squalene	$C_{30}H_{50}$	410.73	8.39
25	22.207	2,2,2-Trifluoroethyl methacrylate	$C_6H_7F_3O_2$	168.11	0.48

Table 3: Chemical composition of *Mimusops elengi* methanol extract

S. No.	RT (min)	Name of the Compound	Molecular Formula	Molecular weight g/mol	Area %
1.	10.842	Oxirane, (2,2-dimethylpropyl)-	$C_7H_{14}O$	114.19	5.14
2.	12.553	Propanoic acid, 2-methyl-2-(3- entadecylphenoxy)-	$C_{25}H_{42}O_3$	390.6	1.95
3.	14.463	5-Eicosyne	$C_{20}H_{38}$	278.5	1.99
4.	15.497	Phthalic acid	$H_2C_8H_4O_4$	166.13	7.04
5.	16.141	inositol	$C_6H_{12}O_6$	180.15	4.28
6.	18.952	Stigmasterol	$C_{29}H_{48}O$	412.70	3.98
7.	21.429	Squalene	$C_{30}H_{50}$	410.73	55.38
8.	22.285	2(1H)Naphthalenone, 3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methylethenyl)-	$C_{15}H_{22}O$	218.33	8.23
9.	23.351	2,6,10,15,19,23-Hexamethyl-tetracosa-2,10,14,18,22-pentaene-6,7-diol	$C_{30}H_{52}O_2$	444.7	9.01
10.	23.496	alpha-tochopherol	$C_{29}H_{50}O_2$	430.7	2.98

Table 4: Larvicidal and pupicidal toxicity of *M. coromandelianum* methanolic extract against dengue vector, *Aedes aegypti*

Target	LC_{50} (LC_{90})	95% Confidence Limit		Regression equation	x^2 (*d.f.* = 4)
		LC_{50} (LC_{90})			
		LCL	UCL		
I instar	378.59 (814.28)	338.88 (698.15)	430.15 (1017.51)	y = -1.114+0.144x	0.408 *n.s*
II instar	404.42 (845.51)	362.36 (721.65)	462.95 (1065.01)	y = -1.175+0.145x	0.316 *n.s*
III instar	415.35 (909.57)	367.81 (759.81)	486.41 (1194.85)	y = -1.077+0.144x	3.721 *n.s*
IV instar	486.01 (980.57)	428.23 (812.41)	584.18 (1308.25)	y = -1.259+0.150x	0.701 *n.s*
Pupa	509.59 (999.14)	999.14 (826.52)	584.18 (1308.25)	y = -1.334+0.154x	1.361 *n.s*

LC_{50} = lethal concentration that kills 50% of the exposed organisms
LC_{90} = lethal concentration that kills 90% of the exposed organisms
LCL = Lower Confidence Limit
UCL = Upper Confidence Limit
χ^2 = chi-square; n.s. = not significant ($\alpha = 0.05$

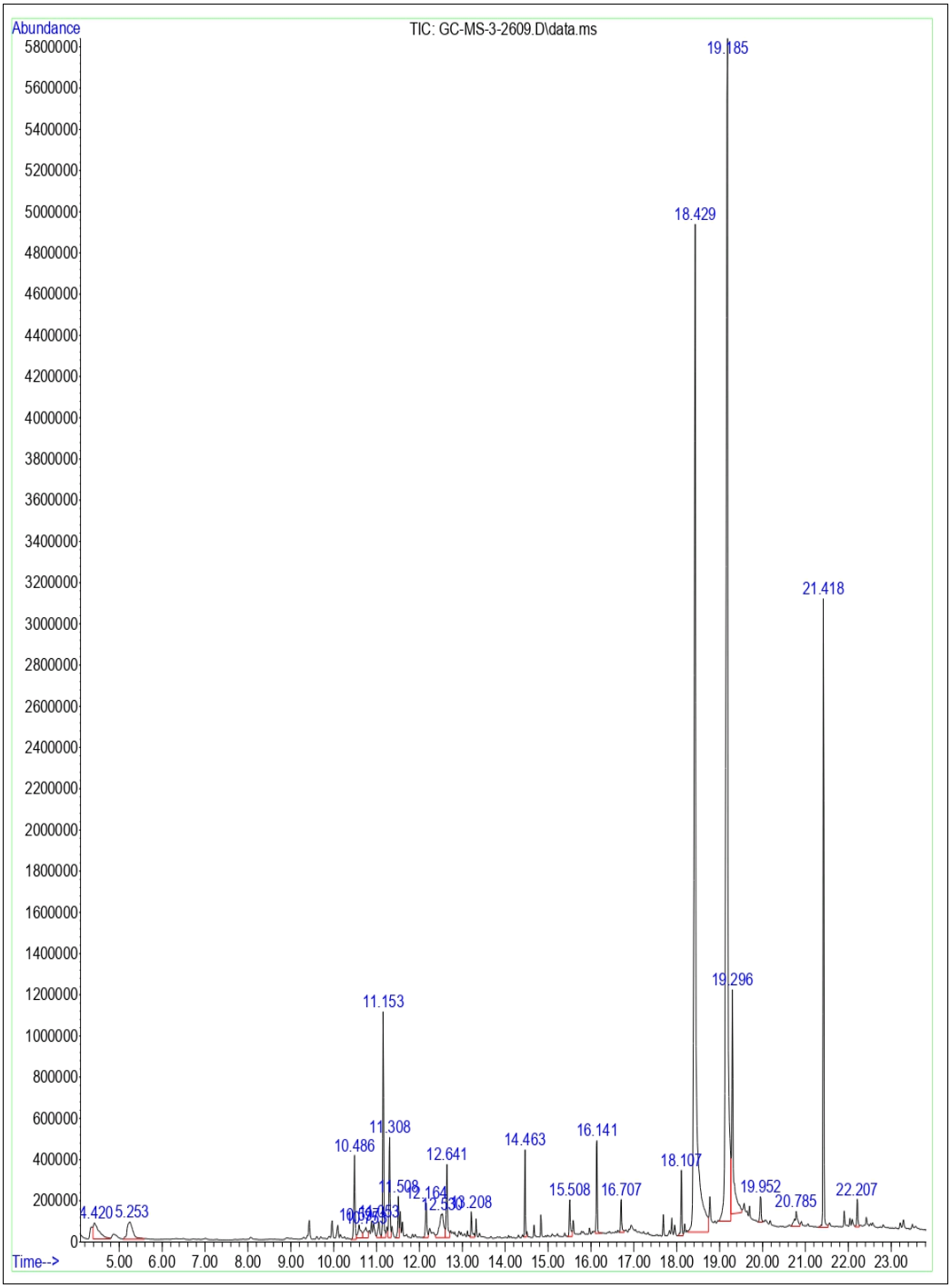

Fig 1: GCMS spectrum of *M. coromandelianum* methanolic leaf extract

Table 5: Larvicidal and pupicidal toxicity of *M. elengi* methanol extract against dengue vector, *Aedes aegypti*

Target	LC_{50} and (LC_{90})	95% confidence Limit		Regression equation	x^2 (*d.f.* = 4)
		LC_{50} (LC_{90})			
		LCL	UCL		
I instar	345.31 (747.11)	309.46 (650.51)	386.79 (908.03)	y = -1.101+0.143x	0.580 *n.s*
II instar	389.62 (813.36)	350.17 (699.77)	441.93 (1009.52)	y = -1.178+0.145x	0.119 *n.s*
III instar	417.41 (910.76)	369.73 (761.03)	448.92 (1195.98)	y = -1.084+0.144x	2.811 *n.s*
IV instar	467.33 (959.52)	412.93 (797.48)	557.06 (1272.45)	y = -1.217+0.149x	1.666 *n.s*
Pupa	499.17 (966.49)	441.70 (807.28)	595.88 (1268.40)	y = -1.369+0.154x	1.047 *n.s*

LC_{50} = lethal concentration that kills 50% of the exposed organisms
LC_{90} = lethal concentration that kills 90% of the exposed organisms
LCL = Lower Confidence Limit
UCL = Upper Confidence Limit
χ^2 = chi-square; n.s. = not significant ($\alpha = 0.05$)

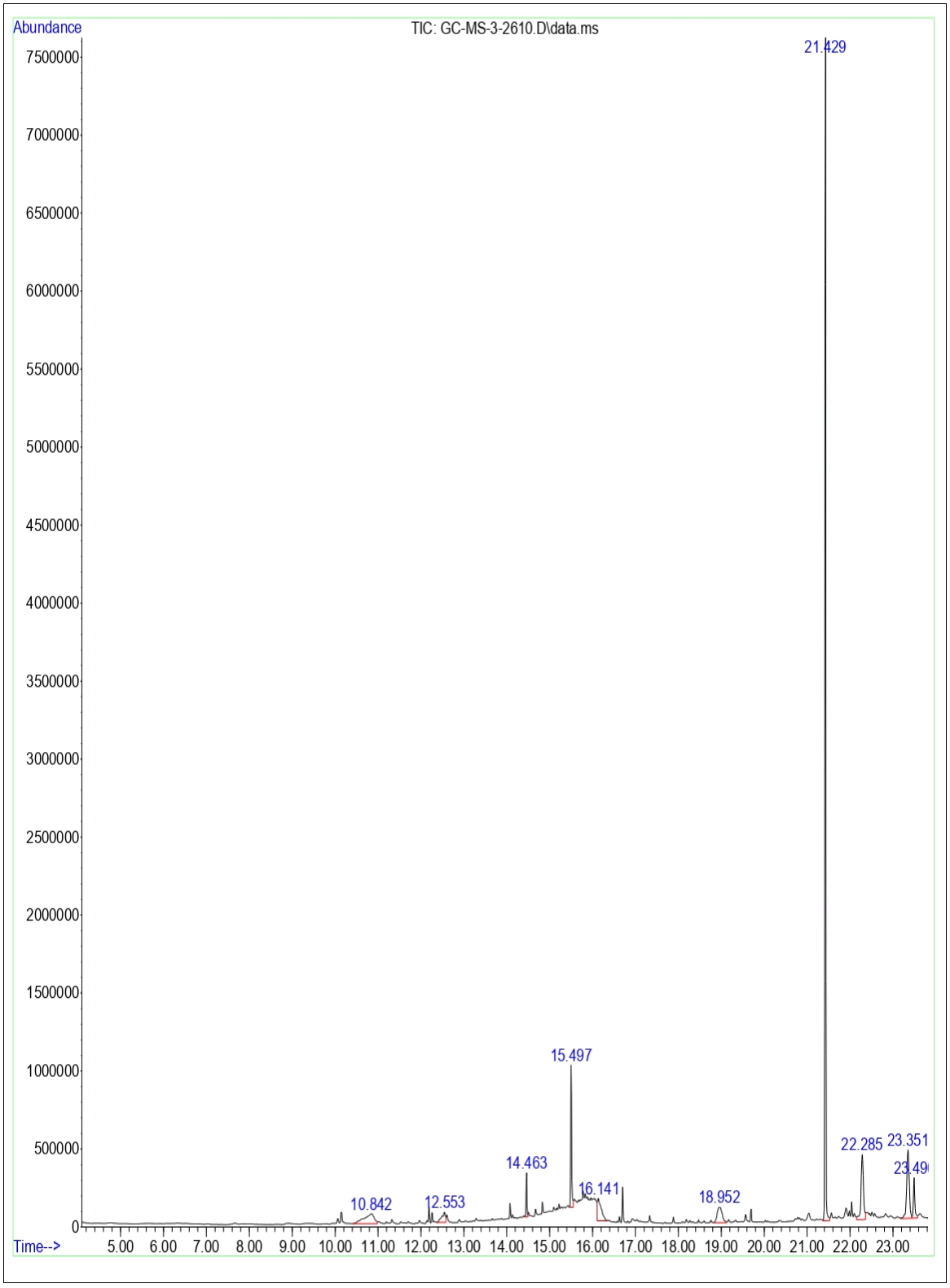

Fig 2: GCMS spectrum of *M. elengi* methanolic leaf extract

Table 6: Ovicidal activity of *M. coromandelianum* and *M. elengi* leaf extracts against dengue vector, *Aedes aegypti*

Treatment	Percentage of egg hatchability					
	Concentrations (ppm)					
	Control	**100**	**200**	**300**	**400**	**500**
M. coromandelianum	99.8±0.3	52.8±0.2	32.4±0.8	15.3±0.9	NH	NH
M. elengi	99.2±0.0	44.5±0.8	20.6±0.3	12.1±0.7	NH	NH

Values were means±SD of five replicates.
NH-No hatchability (100% mortality)

Conclusion

In this study, the GC-MS analysis of the chemical compounds used for the phytochemical compounds was identified in the *M. coromandelianum* and *M. elengi* leaf extracts. The methanolic leaf extract of *M. coromandelianum* and *M. elengi* were the most potential against the eggs and larvae of dengue vector, *Ae. aegypti*. The results suggest that methanolic leaf extract of *M. coromandelianum* and *M. elengi* can be probed further for effective mosquito vector control programme.

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