Eco. Env. & Cons. 29 (1) : 2023; pp. (466-474)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i01.069

Larvicidal, Ovicidal, Ovipositional deterrent and adulticidal activity of *Tagetes erecta* and *Cymbopogon nardus* against *Culex quinquefasciatus* and their GC-MS analysis

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(Received 22 October, 2022; Accepted 28 December, 2022)

ABSTRACT

Culex quinquefasciatus (C. quinquefasciatus) is found in tropical and warm temperate regions and can transmit several viral diseases like Elephantiasis or Filariasis, West Nile fever, St. Louis encephalitis, and Japanese encephalitis causes millions of deaths every year. Long term use of synthetic pesticides to control mosquitoes, has led to the emergence of insecticide resistant vector, ecological imbalance, and harm to mammals, water contamination, toxicity to non-target organisms and residual effects. Therefore, plant based products are being searched and evaluated all over the world as an alternative control. The present study evaluated the efficacy of essential oil of *Tagetes erecta (T. erecta) and Cymbopogon nardus* (*C. nardus)* as a larvicidal, ovicidal, ovipositional deterrency and adulticidal agent against *C. quinquefasciatus*. Various bioassays against the IVth instar larvae, eggs and adults of *C. quinquefasciatus* were carried out. Five different concentrations of 10, 20, 40, 80,160, 320, 640 ppm was prepared for *T. erecta* whereas 20, 40, 80,160,320, 640, 1280 ppm concentrations were prepared for *C. nardus* essential oil to get $LC_{50.}$ Mortality data was calculated by Log-probit method of Finney using SPSS 16 (SPSS 2010) following Abbott method. The GCMS analysis of the essential oil of *T. erecta and C. nardus* was also conducted to estimate the presence of bioactive compunds in the essential oils. The essential oil of *T. erecta and C.nardus*, showed LC_{50} at 42.02 ppm and 160.29 ppm respectively after 24 hours. Whereas LC_{50} after 48 hrs is recorded at 39.25 ppm in *T. erecta* and 94.39 ppm in *C. nardus* against *C. quinquefasciatus*. At 40 ppm, *T.erecta* showed ovicidal activity with 40.99%, ovipositional activity with 57.80% and adulticidal activity with 88.00%. On the other hand, *C. nardus at* 160.29 ppm exhibited ovicidal activity with 77.63%, ovipositional activity with 73.33% and adulticidal activity with 73.6%. Many active phytochemicals was also found in the essential oil of *T. erecta and C. nardus.* It is concluded that the essential oil of both *T. erecta and C. nardus* are very effective mosquitocidal agent against *C. quinquefasciatus.* However *T. erecta* shows more effective results in comparision to *C. nardus.*

Key words : *Tagetes erecta, Cymbopogon nardus, Culex quinquefasciatus, Larvicidal, Ovicidal and Ovipositional deterrent, Adulticidal, GC-MS analysis.*

Introduction

Mosquitoes are well known vectors of several disease causing pathogens and belong to the holometabolas part of *Culicidae* family (Patel, 2017). They transmit many deadly diseases like Malaria, Dengue, Filariasis, Japanese encephalitis, West Nile fever, and Yellow fever and many more. Mosquitoes

show complete metamorphosis with 4 life stages, immature egg, larva, pupa and adult mosquito (Silvério *et al.,* 2020), but it is the adult female mosquito which is a vector as female mosquito are hematophages for their egg maturation (Majumder *et al*., 2020). This implies that the control strategy for the vector can be at any stage of its life cycle (Patel, 2017). *C. quinquefasciatus* is the vector of many deadly diaeases like filariasis, West Nile fever, St. Louis encephalitis, and Japanese encephalitis. Lymphaticfilariasis which is much prevalent in India is caused by *Wuchereria bancrofti* which affects the arms, legs and genitals. It infects 80 million people annually of which 30 million cases exist in chronic infection (Manimaran *et al.,* 2012). Worldwide 47 countries are threatened by *Lymphatic filariasis.* The global baseline estimate of people affected by *Lymphatic filariasis* was 25 million with hydrocele and over 15 million people with lymphoedema. At least 36 million people remain with these chronic disease manifestations (WHO, 2020). Synthetic pesticides like organophosphates, pyrethroids and carbamates are effective (Elumalai *et al.,* 2017), but also leads to the problem of developing resistance, cross-resistance and possible toxicity hazards against non-target animals, bioaccumulation and pollution. This has shifted the focus towards an alternative insecticide which is more eco-friendly, non-hazardous to non-target organisms (Dharmagadda *et al*., 2005). Plants produce secondary metabolites like alkaloids, steroids, terpenoids, essential oils and phenolics as a part of their defence system from herbivory and insects. Essential oil is complex mixture of volatile compounds produced by cells like glandular trichome, adduct cavities and osmophores which are present on all the parts of plants (Jean Baptiste Hzounda Fokou *et al*., 2020). The lipophilic nature of essential oils facilitates their interference with basic metabolic, biochemical, physiological, and behavioural functions of insects (Marques *et al.,* 2011). The Potency of phytochemicals depends on many factors like plant species, geographical varieties and parts used, extraction methodology adapted. *C. nardus (Poaceae)* is a species of monocotyledonous plant, whose essential oil contains mainly citronellal, geraniol and elemolused for cosmetics, pharmaceutics, and perfumery applications (Ahouansou *et al.,* 2018). *T. erecta (Asteraceae*), contain diverse compounds namely phenylpropanoids, carotenoids, flavonoids, thiophenes, and others which exhibit fungicidal, bactericidal, and insecticidal activities, as well as anticancer properties (Rajvanshi *et al.,* 2017, Salehi *et al.,* 2018). The present study is focussed on the efficacy of essential oil of *T.erecta (Asteraceae), C. nardus (poaceae) as* a mosquitocidal agent against *C. quinquefasciatus.*

Materials and Methods

Collection of plant extracts: The flowers of *T.erecta* and leaves of *C. nardus*, were freshly collected during the month of August - September from the natural surroundings of Talegaon, Pune (18.5204° N, 73.8567° E) Maharastra. The collected samples were sent to Botanical survey of India for verification. Later it was dried in shade and upon drying it is powdered by domestic mixers.

Preparation of essential oil: The essential oil is extracted by the hydro distillation method under optimal operating conditions. 100 g of plant product was added to 800 ml of distilled water in a 2-litre flask. The set was placed in a balloon heater attached to a refrigerator to ensure condensation of essential oils for 3 hours. Due to this process, it got separated into two phases, an aqueous phase (aromatic water) and an organic phase (essential oil), less dense than water. Essential oil collected and stored in the dark at 4 °C to avoid any decomposition of active component (Elyemni *et al.,* 2019).

Gas Chromatography-mass spectrometry analysis: Analysis of effective components: For analysis of the constituent compounds of the selected plants, Gas chromatography (Agilent, 7890A) and mass spectrometry (Accu TOF GCv, Jeol) was performed. GC was equipped with a FID detector and a capillary column (HP5- MS). The carrier gas was helium at a flow rate of 1 ml/min. The GC program was set for *T. erecta as* 10; 60-1M-8-200-1M-8-275-10M-5-280 ET and for *C. nardus as* 10; 60-1M-8-200-8-275-10M-5-280 ET.

Identification of major compounds from plants: Major compounds of each plant essential oil were identified based on their area percentage calculated from the GC- chromatogram and mass spectrometry results in reference to NIST standard database (NIST, 2008).

Rearing of Mosquito: The various mosquitocidal assays of essential oil of *T. erecta and C. nardus* were conducted on *C. quinquefasciatus*. The mosquito culture was obtained from Ross life sciences, Pune and reared as per the WHO guidelines. For rearing, adults, larvae and eggs population were maintained

in different set up, (Kauffman *et al*., 2017). Temperature is set at 27 °C ± 2 °C and relative humidity at 75% ± 5% (Imam *et al.,* 2014).

Larvicidal bioassay: WHO guideline was followed to assess the larvicidal effects of essential oil of *T. erecta and C.nardus* on IVth instar larvae of *C. quinquefasciatus*. Three sets of five replication were carried out against *C. quinquefasciatus*. Stock solution (1000ppm), was prepared with 100 mg of test material dissolved in 1ml of acetone and later diluted in 100 ml of distilled water in the conical flask. A series of five concentrations of 10, 20, 40, 80, 160, 320, 640 ppm was prepared for *T.erecta* from the stock solutions. On the other hand 20, 40, 80, 160, 320, 640, 1280 ppm concentrations were prepared for *C. nardus* from the stock solutions In each beaker, 25 IVth instar larvae are added and number of dead larvae was counted after every 24 and 48 hours. Also 25 IVth instar larvae in 1ml of acetone mixed with water to make 100ml were taken as control. During the entire testing time, the room temperature was kept constant at 28 °C ± 2°C. (Elumalai, *et al.,* 2015).

Ovicidal assay: Ovicidal activity was studied as per the method of (Su, T et. al. 1998).To assess ovicidal activity of *T. erecta* and *C.nardus*, five replicates of two concentrations near LC_{50} of larvicidal assay i.e. 10, 20, 40, 60, 80 ppm for *T. erecta* and 120, 140, 160, 180, 200ppm for *C.nardus* extract were prepared and the eggs of *C. quinquefasciatus* were separately exposed to each concentration and egg mortality was observed under the microscope (Reegan *et al.,* 2014). Control group was exposed to acetone. After exposing the eggs for 5 days, percent ovicidal activity was assessed by using the following formula.

$$\text{Percentovicidal activity} \quad \frac{\text{Number of unhatched eggs} \times 100}{\text{Total number of eggs introduced}}$$

Oviposition deterrent assay: The oviposition deterrent test will be performed using the method of (Xue *et al.,* 2001) against *C. quinquefasciatus*. Fifteen gravid females will be (3-days-old, 4days after blood feeding) transferred to each mosquito cage (45*38*38*cm) covered with a plastic screen, with a glass top, and a muslin sleeve for access. A 10% sucrose solution will be made available at all times. For determining the ovipositional effect of essential oil of *T. erecta and C.nardus* one bowls with 100 ml of water and test material will be placed in one corner whereas another with a solvent control was kept in opposite corner. The positions of the bowl will be alternated between the different replicates so as to nullify any effect of position on ovipositonal activity. Three replications for each concentration were done. The experiment was conducted at ambient temperature (27±2ºC) with relative humidity of 70-80%. After 24h, the number of eggs laid in treated and control bowls will be recorded.

The percent effective repellency for each essention oil concentration will calculated using the following formula.

ER%=NC-NT/NC*100

Where, ER=Percent effective repellancy, NC= Number of eggs in control, NT= Number of eggs in treatment

Adulticidal assay: The adulticidal activity of the essential oil of *T. erecta and C. nardus* was evaluated following the WHO standard method. Briefly, essential oil of *T. erecta* and *C.nardus* were dissolved in acetone to prepare a testing concentration of 10 mg/ml. Two and half millilitres (2.5 ml) of testing concentration were impregnated into Whatman No 1. Filter papers (12 × 15 cm). Acetone was used as a negative control. The impregnated papers were air dried for 5 minutes and then inserted into an exposure tube in the WHO testing kit. Twenty, 2–5 day old, blood-starved female mosquitoes of *C. quinquefasciatus* were introduced into the holding tube and held for 1 hour to acclimatize. The mosquitoes were then transferred by gentle blowing in the exposure tube. After 1 hour in the exposure tube, mosquitoes were then transferred back to the holding tube to recover. A pad of cotton soaked with 10% glucose solution was placed on the mesh screen to feed recovering mosquitoes. At the end of the 24-hour recovery period, the numbers of dead mosquitoes were recorded and the percent mortality was calculated. Each essential oil was tested in duplicate and the assay was repeated three times.

Results

GC-MS analysis of these oils identifies 31 active phytochemicals in *T. erecta*, and 28 active phytochemicals in *C. nardus*. The main compounds in *T. erecta* are, 2-hexanone, 1, 1, 1, fluoro, 3,6 octatriene, 3,7-dimethyl-[z], 2,4,6-octatriene,2,6-dimethyl-[e,z], 2-cyclohexen-1-one,3-methyl-6-[1-methylethenyl] in *T. erecta.* On the other hand, main

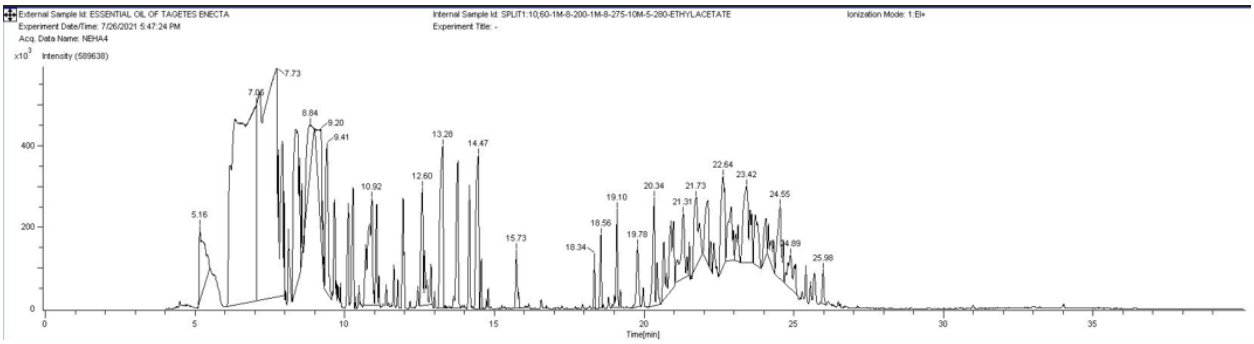


Fig. 1. GC-MS chromatogram of essential oil *T.erecta*.

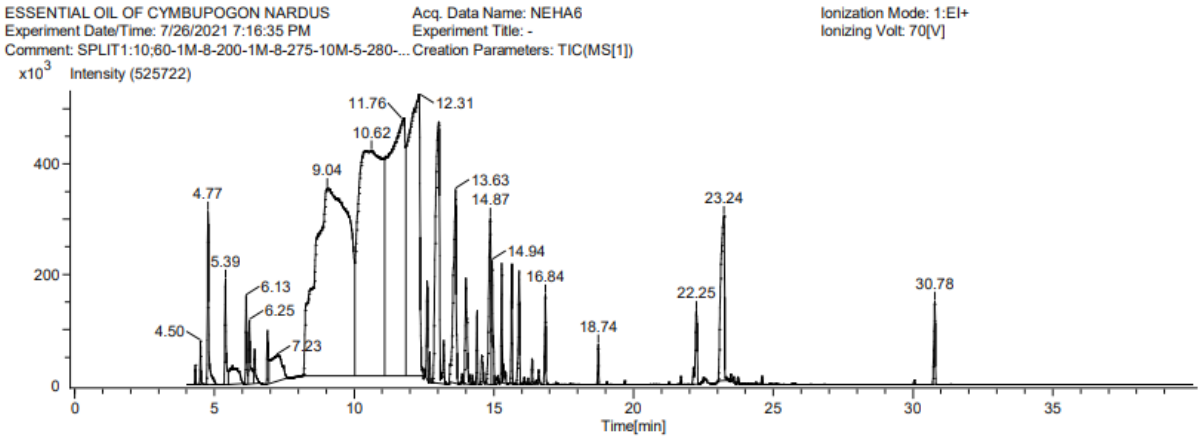


Fig. 2. GC-MS chromatogram of essential oil *C.nardus*

compounds in *C.nardus* are 2,6octadienal, 3,7-dimethyl (z), 2,6 octadienal, 3,7-dimethyl (z), 2,6, octadien-1-ol, 3,7-dimethylacetate

Larvicidal activity: The results of larvicidal activity obtained after exposing IVth instar larvae of *C. quinquefasciatus* to various concentrations of essential oil of *T.erecta* exhibits potent lethality against *C. quinquefasciatus*..Essential oil of *T.erecta* shows 25% - 60% mortality against IVth instar larvae of C. *quinquefasciatus* at 20-40 ppm when exposed for 24 hours, while *C. nardus* kills 25%-50% IV instar larvae of *C. quinquefasciatus* at 40-80 ppm when exposed for 24 hours.

The LC_{50} (lethal concentration that kills 50% of the exposed larvae) and LC_{90} (lethal concentrations that kills 90% of the exposed larvae) of *T.erecta* against IVth instar larvae of *C. quinquefasiatus* after 24 h treatment was 42.02 ppm and 72.16 ppm respectively where as LC_{50} and LC_{90} after 48 hours of exposure was 39.25 ppm and 65.15 ppm respectively. The LC_{50} and LC_{90} of *C. nardus* against IV instar larvae of *C. quinquefasiatus* after 24 h post treatment was 160.29 ppm and 358.56 ppm respectively whereas after 48 hours of exposure it was 94.39 ppm and 162.2 ppm respectively.

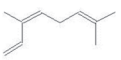
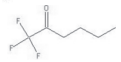
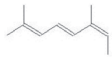
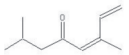
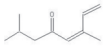
Ovicidal activity: *C.nardus* records 77.63 % ovicidal activity at 160 ppm against *C.quinquefasciatus* and *Tageteserecta* recorded 40.99 % ovicidal activity at 40 ppm against *C. quinquefasciatus*. Control in *Culexquin quefasciatus* shows 5.18% in set I and 8.88% in set II against *C. quinquefasciatus.*

Ovipositional deterrent activity: Among the two essential oil tested for ovipositional detterent activity against *C.quinquefasciatus. T. Erecta* shows 57.8 % repellency whereas *C. nardus* shows 73.33% ovipositional activity.

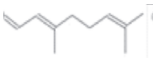
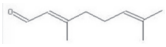
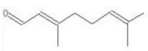
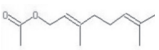
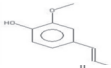
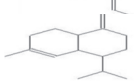
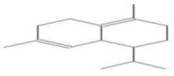
Adulticidal activity: The duration (days) of adult development was recorded after exposure to essential oil of *T. erecta and C. nardus*. Analysis of essential oil revealed the fact that both the essential oil show promising adulticidal activity against *C.quinquefasciatus. T. Erecta* shows 88.00% whereas

Table 1. Major ten phytochemicals identified from *T. Erecta* and *C. nardus* by GC-MS analysis.

Tagetes erecta

Sr. No.	RT	Name of the Compound	Molecular formula	Molecular weight	Molecular Structure	Area {Intens. *sec]
1	5.16	B- Phellendrene	$C_{10}H_{16}$	136		2067133.75
2	7.05	1,3,6 octatriene,3, 7 dimethyl Z	$C_{10}H_{16}$	136		24265965.08
3	7.73	2- Hexanone,1,1,1-trifluoro	$C_6H_9F_3O$	154		24346357.26
4	8.37	2,4,6-Octatriene,2,6-dimethyl,(E,Z)	$C_{10}H_{16}$	136		4974992.97
5	8.84	5,7-Octadien-4-one,2,6-dimethyl-	$C_{10}H_{16}O$	152		2188061.86
6	9.2	5,7-Octadien-4-one,2,6-dimethyl-	$C_{10}H_{16}O$	152		2194924.15
7	9.41	(+)Isomenthol	$C_{10}H_{20}O$	156		2189837.06
8	10.92	2-Cyclohexene-1-one, 3-methyl-6-(1-methylethenyl)-(S)	$C_{10}H_{14}O$	150		3767546.68
9	12.6	Naphthalene1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-1a,4ab,8aα	$C_{15}H_{24}$	204		2215135.64
10	13.28	Carophyllene	$C_{15}H_{24}$	204		2921545.45

Cymbupogon nardus

Sr No.	RT	Name of the Compound	Molecular formula	Molecular weight	Molecular Structure	Area {Intens. *sec]
1	9.04	2,6,-octadienol,3,7-dimethyl-(Z)-	$C_{10}H_{16}O$	152		28615170.9
2	10.6	2,6,-octadienol,3,7-dimethyl-(Z)-	$C_{10}H_{16}O$	152		24376017.1
3	11.7	2,6,-octadienol,3,7-dimethyl	$C_{10}H_{16}O$	152		19182061
4	12.3	2,6,-octadienol,3,7-dimethyl-(E)	$C_{10}H_{16}O$	152		14545709.6
5	12.6	6-octen-1-ol,3,7-dimethyl-acetate	$C_{12}H_{22}O_2$	198		486526.05
6	13	6-octen-1-ol,3,7-dimethyl-acetate(E)	$C_{12}H_{22}O_2$	196		4836370.77
7	13.6	Caryophyllene	$C_{15}H_{24}$	204		2534874.32
8	14	Phenol,2-methoxy-4-(1-propenyl)-(E)	$C_{10}H_{12}O_2$	164		964844.36
9	14.9	Napthelene,1,2,3,4,4a,5,6, 8a-octahydro-7-methyl-4-methylene-1-[1-methylethyl]-[1α,4β,8aα]	$C_{15}H_{24}$	204		1522562.5
10	14.9	Napthelene,1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1[1-methylethyl]-,[1s-cis]	$C_{15}H_{24}$	204		754695.13

C.nardus shows 73.6% adulticidal activity against *C. quinquefasciatus.* On the other hand, the adulticidal activity is negligible in control.

Statistical Analysis: The LC_{50} and LC_{90} values of the essential oil was calculated by SPSS software as the average mortality data were subjected to Probit analysis calculations. 95% fiducial limits of upper confidence limit and lower confidence limit and regression equation were calculated using the SPSS software.

Discussion

Humans were always more susceptible to insect transmitted diseases so their control methods becomes an important task. Due to higher quantities of synthetic insecticides in mosquito control results in progressive contamination of the ecosystems, vector resistance, as well as danger to human health (Macoris *et al.*, 2003). This leads to development and implementation of new mosquito proliferation management programs which is eco-friendly and effective. Natural substances like essential oil is a good alternative to replace synthetic chemical compounds, due to their excellent larvicidal, pupicidal and adulticidal properties and being safe to humans and other mammals as well. Also the synthetic insecticide targets the adult mosquitoes whereas the mosquito control programme with plant products acts by interfering with the growth and reproduc-

Table 2. Mortality percentage of IVth instar larvae of *C. quinquefasiatus* exposed for 24 and 48 h to different concentration of essential oil.

			% Mortality							
	Essential oil	Exposure(h)	Control	10	20	40	80	160	320	640
1	*Tageteserecta*	24	0	3.5	25	55.7	90.3	100	100	100
2	*Tageteserecta*	48	0	2	24.2	59.3	94.5	100	100	100
				20	40	80	160	320	640	1280
3	*Cymbupogonnardus*	24	0	0.2	16	46.7	81.3	91	94	100
4	*Cymbupogonnardus*	48	0	0.7	18.2	58	84	99.5	100	100

Table 3. Lethal concentration of essential oil against IVth instar larvae of *C.quinquefasciatus*

	Essential oil	Exposure (h)	LC50 (ppm)	LC90 (ppm)	Regression equation	95% Confidence limits			
						UCL		LCL	
						LC_{50}	LC_{90}	LC_{50}	LC_{90}
1	*T. erecta*	24	42.02	72.16	y=-1.787+0.043x	51.63	92.57	34.57	60.56
2	*T. erecta*	48	39.25	65.15	y=-1.942+0.0049x	48.08	83.64	32.52	54.77
3	*C.nardus*	24	160.29	358.56	y=-01.401+0.006x	171.34	384.16	159.203	339.31
4	*C.nardus*	48	94.39	162.2	y=-1.784+0.019x	103.1	179.16	86.587	148.96

UCL — upper confidence limit , LCL — lower confidence limit.

Table 4. Effect of essential oil on egg hatchability of *C. quinquefasciatus.*

Sr No.	Essential oil Name	Dose	Insect Species	Parameters	R-1	R-2	R-3	R-4	R-5	Avg	% Ovicidal Activity
1	*T. erecta*	40 ppm	*C. quinque-fasciatus*	Eggs exposed	136	128	146	154	180	148.80	40.99
				Unhatched eggs	74	56	27	68	80	61.00	
2	*C. nardus*	160 ppm	*C. quinque-fasciatus*	Eggs exposed	120	143	106	169	195	146.60	77.63
				Unhatched eggs	109	127	93	139	101	113.80	
3	*Control*	Set- 1	*Culexquin-quefasciatus*	Eggs exposed	141	122	168	148	174	150.60	5.18
				Unhatched eggs	10	2	6	9	12	7.80	
4	*Control*	Set- 2	*Culexquin-quefasciatus*	Eggs exposed	130	111	157	137	163	139.60	8.88
				Unhatched eggs	6	12	16	13	15	12.40	

Table 5. Effect essential oil on oviposition deterrence on*C.quinquefasciatus.*

Esential oil Name	Dose	Insect Species	Parameters	R-1	R-2	R-3	R-4	R-5	Average	% Repellency	Ovipositional Activity Index
T.erecta	40 ppm	*C.quinquefasciatus*	Control	542	432	462	405	517	471.60	57.80	0.41
			Treated	231	167	252	140	205	199.00		
C.nardus	160 ppm	*C.quinquefasciatus*	Control	496	539	378	512	471	479.20	73.33	0.58
			Treated	163	129	108	102	137	127.80		

Table 6. Effect of essential oil for adulticidal activity against *C.quinquefasciatus*

Sr. No.	Essential oil	Insect Species	Replication Reading after 1 hours of Exosure					Average in %	Replication Reading after 24 hours of Exosure					Average in %
			R-1	R-2	R-3	R-4	R-5	Average in Number	R-1	R-2	R-3	R-4	R-5	Average in Number	
1	*T. erecta*	*C. quinquefasciatus*	25	25	25	23	23	24.20	96.80	21	24	23	19	23	22.00	88.0
2	*C.nardus*	*C. quinquefasciatus*	22	24	21	23	22	22.40	89.60	18	20	17	19	18	18.40	73.6
3	*Control Reading- I*	*C. quinquefasciatus*	2	4	3	5	2	3.20	12.80	0	0	2	5	0	1.40	5.6
4	*Control Reading- II*	*C. quinquefasciatus*	2	3	2	4	1	2.40	9.60	2	0	1	4	0	1.40	5.6
5	*Control Reading- III*	*C. quinquefasciatus*	2	2	2	2	1	1.80	7.20	2	1	1	2	0	1.20	4.8

tion of the pest and are effective against different stages of their growth like eggs, larva, pupa and adults (Dharmagaddaa *et al*., 2005). It has popularises the plant products based mosquito control as it is eco- friendly and nontoxic to non-target organisms (Tennyson *et al*., 2013). Essential oil is secondary metabolites mainly rich in monoterpenoid or sesquiterpenoids. They are highly interesting compounds as they exhibit broad range activities like mosquitocidal activity, analgesic, anti-inflammatory, antispasmodic, local anaesthetic, anthelmintic, antipruritic, and antiseptic antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic, antidiabetic, antinociceptive, and antithrombotic properties and antiulcerogens, diuretics, and hepatoprotective effects. (Umaru *et al*., 2019). On comparing mosquitocidal activity of essential oil of *T. erecta* and *C. nardus*, *T. erecta* shows excellent larvicidal activity with a much lower LC_{50} of 42.02 ppm against *C.quiuefasciatus* after 24 hrs, and the results are in accordance with other studies as well which states flowers of *T. erecta* are very effective natural larvicide against *C.quinquefasciatus* with the lowest LC_{50} values for all the instars larvae of *C. quinquefasciatus* (Nikkon *et al*., 2011). *C. nardus* shows LC_{50} of 160.29 ppm after 24 hrs, similar results were obtained which exhibits sensitivity of *C. nardus* essential oil against Anopheles gambiae 3rd instar larvae (Ahouansou *et al*., 2019). In comparision to ovicidal, ovipositional and adulticidal activity of two essential oil, T. *erecta* shows much better results. *T. erecta* shows 40.99% ovicidal effects, 57.8 % ovipositional repellency and 88% adulticidal effects at very lower concentration of 40 ppm whereas *C. nardus* shows 77.6% ovicidal effects, 73.33% ovipositional repellency and 73.6 % adulticidal effects but at higher concentration of 160.29 ppm. It is concluded that the active chemical compounds such as 2-hexanone, 41, 1, 1, fluoro, 3,6 octatriene, 3,7-dimethyl-[z], 2,4,6-octatriene, 2,6-dimethyl-[e,z], 2-cyclohexen-1-one, 3-methyl-6-[1-methylethenyl] in *T. erecta and* 2,6octadienal, 3,7-dimethyl (z), 2,6octadienal, 3,7-dimethyl (z), 2,6, octadien-1-ol, 3,7-dimethylacetate, in *C. nardus.* can be used in pure form to control

the population of C. *quinquefasciatus*.

Conflict of interest: The authorities declare no conflict of interest

Acknowledgements

The authors are grateful to Principal of Prof. Ramkrishna More College of arts, commerce and science, Akurdi, Pune as well as DST and DBT, New Delhi, Savitribai Phule Pune University for providing assistance to carry out the present investigations.

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