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Review on activity of medicinal plant extracts against mosquito genera *Anopheles* & *Culex*

Sabila Afzal[1*], Syed Shakil Shah[2], Samia Ghaffar[3], Sana Azam[4], Faiza Arif[5]
[1-5] University of Narowal Circular road Narowal Punjab, Pakistan

Abstract
Vector-borne diseases are spreading all across the world, which results in economic and social disturbances. *Anopheles* is a genera of mosquitoes that are responsible for the transmission of Malaria worldwide that causes millions of deaths every year. *Culex* is another genera of mosquitoes that transmits Japanese encephalitis, the annual death rate due to JE is 30,000-50,000. However different insecticides are used to control these vector borne diseases successfully such as: Carbamates, Organophosphates, Organochlorines, Pyrethroids Pyrroles and Phenyl pyrazole. Insecticides may be used as indoor sprays or as insecticides treated nets, all these are proved to be effective in eradication of mosquitoes, but these insecticides have some bad impacts as they harms environment, interact with non-targeted species, the major reason of the reduction in use of insecticides is the development of resistance in insects. Insects have altered their target site by alteration in special proteins due to which insecticides are not much harmful for insects. Alternative of these insecticides are plants based products used as larvicides, ovicides, adulticides or as repellents against mosquitoes. Different plant parts are extracted for their use as mosquito codes. Plant parts may be used directly through extraction, or essential oils may be extracted to repel mosquitoes. Essential oils are volatile and are effective as mosquito codes, they possess different fragrances that interact with the olfactory receptors of mosquitoes and repel them. Different plant essential oils are used for this purpose, as Neem oil extracted through seeds of *Azadirachta indica* used to repel 96-100% mosquitoes of *Anopheles* genus and 61-94% mosquitoes of *Culex* genus. Extracts of Garlic plant (*Allium sativum)* are used for killing of larva of *Anopheles stephensi* and *Culex quinquefasciatus* mosquitoes. Some other plants like *Citrullus colocynthis, Ocimum basilicum, Cymbopogon winterianus Jowitt, Dysoxylum malabaricum, Khaya senegalensis, Ficus benghalensis, Mentha piperita* etc. are some plants used successfully for elimination of mosquitoes in a natural way.

Keywords: *Culex*, *Anopheles*, essential oils, mosquito repellents, plant extracts

Introduction
Mosquitoes are of great importance due to the transmission of various diseases like pathogens, species of virus, nematodes and protozoa, they pose a great health threat till today. Mosquitoes act as a vector for-fatal human diseases like Malaria, filariasis, dengue, yellow fever, encephalitis and virus infections etc. in all around the world [1]. Mosquitoes are responsible for infecting more than 700 million people every year in more than 80 countries, approximately 20% of the world's population is at risk of acquiring infections of mosquito's borne-diseases. Most of them live in Asia, the Pacific, and the Americas, one third live in India and one third in Africa [2]. This not only higher the Mortality rate but also have economic and social disturbances in developing countries like India and China etc. The global contribution of India in Filariasis burden is 40% and the economic loss is about 720 corers. The annual mortality rate is 30,000-50,000 and annual estimation for Japanese encephalitis (JE) is 10,000 [3].

Anopheles mosquitoes are distributed worldwide except in cold temperate regions, over 400 species of *Anopheles* are known that are pathogenic to humans. Almost 30 species transmit Plasmodium significantly in nature [4]. Malaria is one of the most important reasons of infant, child, and adult death in India. *Anopheles subpictus* is scattered in India, Afghanistan, Borneo, China, Malaysia, Philippines Si Lanka, Java, and Indonesia. *An. subpictus* is the secondary vector for Malaria in Sri Lanka, and *An. culicifacies* is the main vector for Malaria. *An. subpictus* is identified as the secondary vector for Malaria in South East Asia, most of the cases are reported from India. *Culex tritaeiniorhynchus* is responsible for Japanese encephalitis and distributing this virus to Southeast Asia; and South Asia [5]. Virus that is responsible for Japanese encephalitis is an Arbovirus which is spread by marsh birds and transmitted through biting of infected *Culex tritaeiniorhynchus* mosquitoes. 14 countries are at risk of outbreaks of Japanese encephalitis with 3060 million people are at risk of infection. Out of these 14 countries, China and India are most susceptible for these outbreaks with 2 about 700 million people potentially at risk of infection [6]. Unfortunately, specific treatment for arbovirus is still unknown. Therefore, the curtailment of mosquito vectors is necessary for public health [7]. The infections spreading in Asia, Southeast Asia, Africa and the Americas are 90% caused by *Wuchereria bancrofti*, main vector for *Wuchereria bancrofti* are mosquitoes of *Culex* specie i.e. *Culex quinquefasciatus* [2].

Mostly the rate of prevalence of mosquitoes increase in fish pond, irrigation ditches and rice fields during rainy season due to poor drainage system, which provides mosquitoes a better place for breeding [9]. Mosquitoes control is essential to prevent these vector borne diseases [10]. So approaches to

interrupt the disease transmission by these vectors are killing of mosquitos and preventing mosquito bites [8]. Mosquito control has become more difficult due to the unsystematic use of synthetic chemical insecticides which have inauspicious effect on the environment; they also effect man and animals because they are not properly degradable and spread their toxic effect [7]. The larval stages of mosquitoes can easily eradicated for control operations because they are less movable in larval forms than the adults [12]. To control or eliminate mosquito population highly efficacious pesticides have been employed. These pesticides are threatened due to the developing resistance of mosquitoes against them [15]. Different strategies are used to control these disease vectors. One of which is indoor residual spraying and Insecticide treated nets. DDT spray is used and have proven to be very successful in executing disease vectors but also have been resulted in the development of insecticide resistance in Mosquitoes. Similarly some other compounds like Organophosphates and Carbamates, have been introduced in indoor residual spraying that eradicated mosquitoes successfully but also have resulted in subsequent development of resistance against these insecticides [13].

There are six classes of insecticides used against mosquitoes these are; Organophosphates, Carbamates, Organochlorines, Pyrethroids and synthetic Pyrethroids Pyrroles and Phenyl pyrazole. Insects have developed metabolic detoxification of insecticides that makes insects resistant, to insect these insecticides act on special target proteins called target-site insensitivity. Study of genes associated with resistance development reveals how these high levels of resistance develop in mosquitoes. Structural changes occur in proteins made by genes are responsible for the resistance development, gene over-expression, amplification and mutation in coding regions of genes. Second reason of resistance development is transcriptional over-expression of genes. Not only these mechanisms are involved in the resistance development but also the interaction of regulatory and resistance genes (that are responsible for development of resistance). It is still unknown how many genes are involved in resistance development [14]. Alternate to these, synthetic pesticides are plants and its isolated compounds for the control of mosquitoes, due to the presence of bio-active chemicals in them, these bio-actives are eco-friendly and act against target insect species. Plants are used for managing of insects for centuries in human communities. Secondary metabolites of plants play a vital role in defense mechanism against insect attacks. These alternative agents may act as repellents, anti-feedants, moulting hormones, juvenile hormone, growth inhibitors, anti moulting hormones, attractants and insecticides [16].

Secondary Metabolites of plants are not for the growth and development of plants in which they are present but they may be associated with some kind of defense mechanism against fungi, bacteria or viruses attack. As they cannot escape from the attack of their predators, they do not have any immune system for their survival but they possess some alternative mechanism in the form of chemical defence. They have allelochemicals in their cells that have some biological effects on the interacting organism [17]. Plant extracts are best options for eradication of mosquitoes as they are less harmful to environment and non-targeted species. The top priority for finding a new insecticide is that they may be originated from plants and they must be eco-safe. Different plant extracts such as Saponin, Steroids, Isoflavonoids, Essential oils, Alkaloids and Tennis are used as mosquito larvicides [12].

Plant derived compounds used as mosquito codes

Different plant products are used either for killing larva or adult mosquitoes, depending upon the activity of mosquitoes. Plant products can also be used as repellents against mosquito bites. A large number of medicinal plants have been reported as mosquito codes and larvicides but only a few number of plant parts are utilized practically for mosquito control.

Medicinal plant parts are used as insecticides including Nicotine, Rotenone and Ryania. Nicotine is neurotoxic and fast acting agent against mosquitoes. Symptoms are similar to that of insecticides Organophosphates or Carbamates, which work as contact poisons. Rotenone are derivatives of legume plants, *Derris* and *Lonchocarpus.* Ryania is extracted by South American shrub, *Ryania* sp. it is toxic as it blocks Ca++. Pyrethrum is extracted by dried flowers of *Chrysanthemum cinerariifolium,* all these components act as insecticidal. *P. longum* fruit extracts have a strong mosquito larvicidal activity at 40ppm. Oils and seeds of Neem tree has been used against the *An. stephensi* and *An. culicifacies* mosquitoes such as inhibiting the formation of their eggs, also reduces the biting of *An. gambiae* to 20.8% . Thermal expulsion to evaporate volatiles from the leaves of *Lippia uckambensis* reduces biting of *An. gambiae* by 49.5%. Repeating the same process with Neem oil reduces the biting process to a modest extent (<25%). Neem oil in coconut oil at different concentrations like 0.5, 1 and 2% provides 100% protection against *An. culicifacies* for 12 hours. Leaves of *Lantana camara* are used as *An. gambiae* repellent and provide protection to about 42.4% [17] Fig.1

Essential oils contains complex mixtures of volatile compounds and are derived from plants, essential oils consist of Alcohols, Esters, Ether, Aldehyde, Ketones, Lactones, Phenols, and Terpenes, Sesquiterpenes. All of these are oxygenated compounds and hydrocarbons respectively. Essential oils are derived from plants and have high repellency against mosquitoes and other arthropods. These oils interact with the hairs present on the antennae of mosquito. These hairs are sensitive for temperature and moisture, when these oils are applied they interact with the olfactory receptors of female mosquitoes and block their sense of smell, which act as an hurdle in the recognition of host body by the mosquitoes. These volatile oils also lower the population of mosquitoes as they disrupt the mating behavior of mosquito by blocking of antennal sensilla that result in unsuccessful mating, ultimately resulting in low population rate [16].

***Allium sativum* L.**

Common name of *Allium sativum* L. is Garlic, extracts of garlic are used for killing of larva of *Anopheles stephensi* and *Culex quinquefasciatus* mosquitoes, also the oil bulbs manifest to have larvicidal activity against *Culex pipiens* [18].

***Citrullus colocynthis* L. Schrad.**

Common name of *Citrullus colocynthis* L. Schrad is bitter apple, bitter cucumber or desert ground. *Citrullus colocynthis*

is a medicinal plant used as a repellent for mosquitoes that kills the egg and larva of mosquito, leaf extracts of *Citrullus colocynthis* act as larvicidal against the early fourth instar larva of *Culex quinquefasciatus.* Extracts of the whole plant act as larvicidal against the early fourth instar larva of *Anopheles stephensi* and the seed extracts kills the third instar larvae of both *Culex quinquefasciatus* and *Anopheles stephensi* [18].

***Ocimum basilicum* L.**

Ocimum basilicum also known as great basil, essential oils of this plant act as a repellent for mosquito specie *Anopheles stephensi, Culex quinquefasciatus* and some females of *Culex pipiens*. Extracts of stem of *Ocimum basilicum* plant exhibits larvicidal activity against *Culex quinquefasciatus* [18].

Azadirachta indica

Azadirachta indica plant belongs to the family Meliaceae, it is an ever green tree found in India and Southeast Asia. In Pakistan known as Neem tree. The essential oil of *Azadirachta indica* is Neem oil which acts as a pesticide and is extracted from seed of the plant. It has been used for centuries to control insects. It has a bitter taste due to the presence of triglycerides and triterpenoid compounds. The main component of Neem oil that makes it repellent for insects is Azadirachtin that kills and repel pests. Neem oil is used against mosquitoes as well, Kerosene lamp having 1% neem oil are effective for repelling mosquitoes and it was proven by the Malaria Research Centre of Delhi in 1994. The degree of repelling mosquitoes was greater for the *Anopheles* specie and then for *Culex* specie. Neem oil can be applied as a personal protective measure against mosquitoes, if 2% Neem oil is mixed with Coconut oil and this mixture is applied to the human body parts that are in direct interaction with mosquitoes, it will provide 96-100% protection against *Anopheles* mosquitoes and 61-94% against *Culex* mosquitoes. Neem does not act as ovicidal or larvicidal to mosquitoes because it cannot kill mosquitoes right away, it only can repel them and prevent biting [19].

Cymbopogon winterianus Jowitt

Commonly known as Citronella, a plant of family Cardio Pteridaceae mostly found in India and tropical Asia. Citronella gives an essential oil called citronella oil that is extracted by Chopping small segments of dried grass. Citronella oil varies in color from colorless to light yellow having a grassy or lemony odour. Citronella is less toxic therefore can be used easily around home. It is used to repel mosquitoes and prevents biting it is used as an alternative of insect repellent DEET (N,N-Diethyl-3-methylbenzamide) therefore it is used more preferably in different form for example in citronella oil repelling candles and cartridges. Citronella oil has some active compounds that are necessary for its function to repel mosquitoes, these compounds are camphor, eucalyptol, eugenol, linalool, citronellal and citral. These compounds interact with the olfactory receptors of mosquito, they have olfactory co-receptors Or83b which responds to the synthetic repellent DEET and thereby interferes the citronellal repulsion. Recent studies have revealed that mosquito species *Anopheles gambiae* have olfactory receptors that can sense Citronellal molecules by olfactory neurons and this sense of detection is controlled by TRPA1 gene that is activated directly by molecules of high adequacy [19].

Dysoxylum malabaricum

Commonly known as white cedar, methanolic extracts of leaves of this plant were investigated for larvicidal, pupicidal, adulticidal and anti-ovipositional activity against *An. stephensi*. 4% methanolic extracts of the plant gives 90% larvicidal, pupicidal, adulticidal against *An. stephensi.* Also it lowers the population rate by inhibiting the reproductive cycle of adult mosquitoes. A research study was conducted in which researchers treated ethyl acetated extracts of *D. malabaricum* with 3β, 24, 25-trihydroxycycloartane and beddomeilactone to test the larvicidal, pupicidal, adulticidal activity against *An. stephensi*. At 10ppm concentration of 3β, 24, 25 trihydroxycycloartane and beddomeilactone they have shown 90% larval mortality rate, both these compounds inhibit the growth of *An. stephensi.* Another plant is *D. binectariferum*, leaf extracts of this plant at the concentration of 18000 ppm reveals 97.5% larvicidal activity and the callus extracts have shown 98.75% larvicidal activity at the rate of 20000 ppm [20].

Khaya senegalensis

Common names of *K. senegalensis* are African Mahogany or Khaya wood, seed of this plant is extracted in different ways that are in Acetone, ethanol, hexane and methanol. These extracts were tested to check the larval mortality rate against *Cx. Annulirostris.* Different seed extracts were used at different concentrations as ethanol 5.1, hexane 5.08, methanol 7.62 and acetone 12mg/L. These extracts have 100% mortality rate at the concentration of 100mg/L with LC50 [20].

Ficus benghalensis

Ficus benghalensis common name is Banyan, it has toxicity levels for mosquito species *Culex quinquefasciatus* and *Anopheles stephensi.* This plant was proved larvicidal against different larval stages of both *Culex* and *Anopheles* mosquitoes. The data were taken at LC50 and LC90 values 95% confidence limits were calculated by using chi-square test. The methanolic extracts of *Ficus benghalensis* act as larvicides against early, second, third and fourth instar larvae of *Culex quinquefasciatus* and *Anopheles stephensi,* different values of LC50 were given by *Culex quinquefasciatus* for different larval stages, at second larval stage it gives 41.43 LC50 value, for third stage LC50 value is 58.21 and for fourth instar larva value is 74.32ppm. Values given by *Anopheles stephensi* for second stage 60.44, for third stage it was 76.41 and for fourth stage it was 89.55ppm. According to this research study, second instar larval stages were more sensitive as compared to third and fourth instar larval stages [21] Table. I, II.

Mentha piperita

Common name of *Mentha piperita* is a pepper mint. It is a perennial herb of Labiatae family which grows 30-90 cm high. Leaf extracts of *Mentha piperita* gives peppermint oil, this essential oil have remarkably strong repelling properties against different mosquito species *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus.* Peppermint oil when applied to human skin that is in direct contact with

mosquitoes, showed strong repellent action. 100% protection is provided by peppermint oil against *An. annularis*, 92.3% against *An. culicifacies* and 84.5% against *Cx. quinquefasciatus* [19].

According to a recent research study, essential oils obtained from *Mentha longifolia*, and *Lavandula dentata* have insecticidal and repellent activity against female of *Culex pipiens*, this study have shown essential oils from *Lavandula dentata* have higher repellent activity against adults of *Culex pipiens* than the oils obtained from *Mentha longifolia*. The longest time of protection was given by L. *dentata* oil that was recorded 165 min at µl/cm2, when it is mixed with paraffin oil. Studies revealed that these two oils are more effective than any other commercial material. Essential oils from different plants like *Mentha aquatica*, *M. longifolia*, *M. spicata*, *M. suaveolens*, *M. piperita*, *M. piperita* var. Crispa, *M. villosa*, and *Pulegium vulgare* were taken as samples and tested for their larvicidal activity against *Culex quinquefasciatus*. These essential oils were obtained by hydro-distillation and then analysed by Gas chromatography-mass spectrometry, this research revealed 50-90% larval mortality rate, from these results researchers concluded that essential oil of *M. longifolia* and *M. Suaveolens* have a highest level of piperitenone oxide and thereby having a highest larvicidal effects [16].

Lansium Domesticum.

Langsat is the common name of *Lansium Domesticum.* Parts of this plant are extracted in aqueous solution, and this extracted material exhibits larvicidal properties against *Cx. quinquefasciatus* [20].

Some other plants have repellent action against mosquito specie *Anopheles* and *Culex*. Table. III

Comparison of plants for highest mortality rate

In another research study five plants were taken to check the which one have essential oils with highest mortality rate for *Culex quinquefasciatus*, these five plants were; *Acorus calamus*, *Mentha arvensis*, *Ocimum basilicum*, *Saussurea lappa* and *Cymbopogon citratus*, essential oils extracted from various parts of plants and investigated their larvicidal properties against *Culex quinquefasciatus*. From this investigation researchers concluded that *O. basilicum* have the highest larvicidal activity against *Culex quinquefasciatus* with LC50 value (LC- lethal con centration). Some other essential oils from different plants were investigated such as: *Zanthoxylum limonella*, *Zingiber officinale*, *Curcuma longa* and *Cymbopogon citratus*, at the end of this study researchers have results about the essential oil from the plant *Zanthoxylum limonella* has shown the highest larvicidal effect against *Culex quinquefasciatus* with LC50 value [16].

Cymbopogon excavates plant is practiced as a mosquito repellent in South Africa *An. arabiensis*, it is a good repellent only for two hours, as the repellency is decreased to 59.3% after four hours [17].

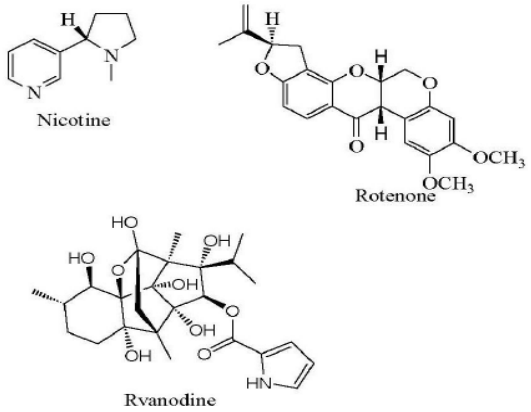

Fig 1: Nicotine, Rotenone, Ryanodine

Table 1: Larvicidal activity of *Ficus benghalensis* against different larval stages of *Culex quinquefasciatus*.

Instars	Solvents	LC50 (ppm)	95% confidence limits (ppm)		LC90 (ppm)	95% confidence limits (ppm)		χ2 value
			LCL	UCL		LCL	UCL	
2nd instar	Methanol	41.43	35.79	46.27	89.48	82.30	99.26	4.972a
	Benzene	71.61	58.69	82.13	170.29	170.29	156.04	1.892a
	Acetone	143.02	115.64	165.00	359.68	326.57	407.14	2.109a
3rd instar	Methanol	58.21	50.72	64.76	127.32	116.18	143.07	1.673a
	Benzene	98.55	82.47	111.88	230.02	210.35	257.36	1.849a
	Acetone	156.27	129.44	178.27	328.67	346.44	435.34	1.684a
4th instar	Methanol	74.32	65.66	82.10	157.66	143.86	177.20	1.035a
	Benzene	104.77	88.07	118.68	246.83	224.68	278.31	0.712a
	Acetone	177.17	152.84	198.28	403.58	365.57	458.81	0.470a

Significant at $P<0.05$ level. LC50: lethal concentration; LCL: lower control limit; UCL: upper control limit [21].

Table 2: Larvicidal activity of *Ficus benghalensis* against different larval stages of *Anopheles stephensi*.

Instars	Solvents	LC50 (ppm)	95% confidence limits (ppm)		LC90 (ppm)	95% confidence limits (ppm)		χ2 value
			LCL	UCL		LCL	UCL	
2nd instar	Methanol	60.44	55.27	65.65	115.55	105.46	129.26	1.544a
	Benzene	125.19	112.94	136.43	249.36	226.52	283.48	1.881a
	Acetone	193.27	115.83	223.46	430.91	392.25	485.25	4.283a
3rd instar	Methanol	76.41	69.29	83.64	153.39	138.49	175.35	0.383a
	Benzene	145.83	120.02	166.86	354.23	322.47	399.28	5.084a
	Acetone	275.43	242.37	306.37	617.17	551.42	717.76	0.355a
4th instar	Methanol	89.55	80.99	98.08	181.24	163.81	206.84	0.203a
	Benzene	169.04	142.93	191.08	403.51	364.12	461.58	2.344a
	Acetone	312.90	279.55	347.57	680.38	601.30	805.86	0.335a

A Significant at $P<0.05$ level. LC50: lethal concentration; LCL: lower control limit; UCL: upper control limit [21].

Table 3: Essential oils that have shown larvicidal and mosquito repellent activity

Mosquito specie Name	Plant specie	Family name	Plant part used	Reference
Anopheles stephensi	*Kaempferia galanga*	Lamiaceae	Rhizome	[16]
Anopheles stephensi	*Syzygium aromaticum*	Myrtaceae	Flower	[16]
Anopheles stephensi	*Mentha piperita*	Acoraceae	Commercial	[16]
Anopheles stephensi	*Myrtus caryophyllus*	Lauraceae	Commercial	[16]
Anopheles stephensi	*Acorus calamus*	Cardiopteridaceae	Commercial	[16]
Anopheles stephensi	*Cinnamomum*	Myrtaceae	Commercial	[16]
Anopheles stephensi	*zeylanicum*	Rutaceae	Commercial	[16]
Anopheles stephensi	*Citronella mucronata*	Rutaceae	Commercial	[16]
Anopheles stephensi	*Eucalyptus tereticornis*	Lamiaceae	Commercial	[16]
Anopheles stephensi	*Citrus limon* (L.)	Lamiaceae	Commercial	[16]
Anopheles stephensi	*Citrus sinensis*	Lauraceae	Leaves	[16]
Culex. quinquefasciatus	*O. basilicum*	Lamiaceae	Shoot	[16]
Culex. quinquefasciatus	*Rosmarinus offinalis*	Lamiaceae	Bark	[16]
Culex. quinquefasciatus	*Cinnamomum*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Zeylanicum*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha aquatica*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha longifolia*	Caryophyllaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha spicata*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha suaveolens*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha piperita*	Myrtaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha villosa*	Acoraceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha pulegium*	Lauraceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Mentha piperita*	Cardiopteridaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Myrtus caryophyllus*	Myrtaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Acorus calamus*	Rutaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Cinnamomum*	Rutaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*zeylanicum*	Lamiaceae	Stage of full Bloom	[16]
Culex. quinquefasciatus	*Citronella mucronata*	Lamiaceae	Commercial	[16]
Culex. quinquefasciatus	*Eucalyptus tereticornis*	Lauraceae	Commercial	[16]
Culex. quinquefasciatus	*Citrus limon* (L.)	Gramineae	Commercial	[16]
Culex. quinquefasciatus	*Citrus sinensis*	Zingiberaceae	Commercial	[16]
Culex. quinquefasciatus	*Mentha piperita*	Lamiaceae	Commercial	[16]
Culex. quinquefasciatus	*O. basilicum*	Solanaceae	Commercial	[16]
Culex. quinquefasciatus	*Cinnamomum*	Poaceae	Commercial	[16]
Culex. quinquefasciatus	*Zeylanicum*	Lamiaceae	Commercial	[16]
Culex. quinquefasciatus	*C. citratus*	Rutaceae	Fresh leaves	[16]
Culex. quinquefasciatus	*Zingiber officinalis*	Lamiaceae	Leaves	[16]
Culex. quinquefasciatus	*Moschosma*	Myrtaceae	Bark	[16]
Culex. quinquefasciatus	*C. winterianus*	Myrtaceae	Fresh Leaves	[16]
Culex. quinquefasciatus	*Solanum*	Myrtaceae	Rhizomes	[16]
Culex. quinquefasciatus	*xanthocarpum*	Myrtaceae	Fresh Leaves	[16]
Culex. quinquefasciatus	*O. americanum*	Myrtaceae	Leaves	[16]
Culex. quinquefasciatus	*Z. limonella*	Myrtaceae	Leaves	[16]
Culex. quinquefasciatus	*Pogostemon cablin*	Myrtaceae	Leaves	[16]
Culex. quinquefasciatus	*Syzygium aromaticum*	Myrtaceae	Commercial	[16]

Commercial—Essential oils purchased commercially

Conclusion

Chemical pesticides and insecticides are used now a days for controlling vector borne diseases, these chemical insecticide act as repellents, larvicidal, ovicidal and adulticides, they also inhibit growth of these vectors to control their population, in this way these synthetic insecticides are used to eradicate mosquitoes to prevent different diseases. The high consumption of these insecticides causes different harmful effects in environment. One of these effects is that these insecticides also interact with the non-target species along with the target species in both terrestrial and aquatic environment. Although the consumption of synthetic insecticides have readily increased in both developing and developing countries, that ultimately have led to the development of resistance against these insecticides. (Basker K *et al*., 2016). In this condition we have to find out more effective strategies to eradicate these mosquitoes from our environment, these strategies must be of eco-friendly and do not harm public health. Synthetic insecticides have bad impacts on soil, water, air and also on the food, they contaminate the food that we eat. In order to avoid all these hazardous effects of synthetic insecticides, we must use the above mentioned plants and essential oils extracted by these plants, these plant based insecticides are herbal based and do not affect the environment and public health.

One of the best example of these plant derived insecticides is "Neem" extracted from *Azadirachta indica* and have high repellents, antifeedants, insecticidal, larvicidal activity and also act as a growth inhibitor of mosquitoes. Several other plants have been used as insecticides as mentioned above, *Allium sativum* L. *Citrullus colocynthis* L. *Schrad. Ocimum basilicum* L. *Azadirachta indica. Cymbopogon winterianus Jowitt. Dysoxylum malabaricum. Khaya senegalensis. Ficus benghalensis. Mentha piperita etc.*

Some plants have essential oils that repel mosquitoes, the level of repellency of medicinal plant is tested as crude material, essential oil or as individual segments. Essential oils are volatile and found in most plant species, these oils have a wide range of applications such as in pharmaceutical as an enhancer in food products, as an odorant in fragrance and also as insecticides. Essential oils as insecticides have many beneficial effects as they are less toxic to mammals, they have bioactive compounds that shows a high level of activity and these oils are rapidly degradable in the environment. They repel mosquitoes due to the presence of some phytochemicals like; Citronellal, Azadirachtin, linalool and p-Menthane-3,8-diol extracted form citronella plant, neem, lavender and mentha plant. By applying these essential oils we can prevent mosquito biting at different levels of protection depending upon the oil or plant part used. Therefore, this review was conducted to aware people how to keep mosquitoes away from the environment that in turns will provide an environment with much less levels of mosquitoes/vector borne diseases (Geetha R V and Roy A. 2014). Keeping mosquitoes away from the environment in a natural way also make environmental conditions much better to live as the natural/botanical procedures for eradication of mosquitoes is not harmful for environment.

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