African Journal of Biotechnology Vol. 6 (5), pp. 631-638, 5 March, 2007
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2007 Academic Journals

Full Length Research Paper

Evaluation of larvicidal activity of the leaf extract of a weed plant, *Ageratina adenophora*, against two important species of mosquitoes, *Aedes aegypti* and *Culex quinquefasciatus*

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Accepted 15 January, 2007

An attempt is made in the present study to analyse the larvicidal effect of the leaf extract of a vastly grown (in the hilly regions of the Nilgiris district) weed plant, *Ageratina adenophora* on two important mosquito species, *Aedes aegypti* and *Culex quinquefasciatus*. The larval mortality of fourth instar larvae of *A. aegypti* and *C. quinquefasciatus* after 24 h of treatment were observed separately in control, 50, 100, 150, 200, 250, 300, 350, 400, 450 and 500 ppm concentrations of the leaf extract (acetone) of *A. adenophora*. Based on the Probit analysis, the 24 h Lc_{50} value of the leaf extract of *A. adenophora* was found to be 356.70 ppm for *A. aegypti* and 227.20 ppm for *C. quinquefasciatus.* When compared to neem, the leaf extract of *A. adenophora* is more toxic to both *A. aegypti* and *C. quinquefasciatus* and could be effectively used for the control of mosquito larvae.

Key words: Eupatory, *Ageratina adenophora, Aedes aegypti, Culex quinquefasciatus*.

INTRODUCTION

The mosquito is the principal vector of many of the vector-borne diseases affecting human beings and other animals. Mosquitoes constitute a major public health problem as vectors of serious human diseases (El Hag et al., 1999). Hubalek and Haluzka, (1999) reported that *Culex pipiens* is the vector of West Nile Virus which causes encephalitis or meningitis which is known to affect the brain tissue, finally resulting in permanent neurological damage. Several mosquito species belonging to genera *Anopheles*, *Culex* and *Aedes* are vectors for the pathogens of various diseases like malaria, filariasis, apanese encephalitis, dengue fever, dengue haemorrhagic fever and yellow fever (Hubalek and Haluzka, 1999). *Aedes aegypti* is the principal vector of dengue fever and dengue hemorrhagic fever and it is reported to infect more than hundred million people every year in more than 110 countries in the tropics (Halstead, 2000).

One of the approaches for control of these mosquito-Borne diseases is the interruption of disease transmission by either killing, preventing mosquitoes to bite human beings (by using repellents) or by causing larval mortality in a large scale at the breeding centres of the vectors. Conventional pesticides such malathion, DDT and pyre-throides that are generally used for mosquito control are known to cause the problem of environmental pollution, residual effects and resistance by their indiscriminate use. Development of resistance to malathion (Guneady et al., 1989) and to deltamethrin (Chen Wen-Mei, 1990) in adult *C. pipiens* has been reported.

Due to the problem of pollution and vector resistance, safe plant products are being tested around the world as pest control agents. Table 1 provides a detailed review of plant products reported for insecticides, growth inhibition and repellent activity against mosquito vectors.

A survey of literature on larvicidal effects of plant products on mosquitoes indicates that most of the studies included well known horticultural and commonly grown plants. On the other hand, the larvicidal activity of weed plants that is found in vast areas on plains as well as on hilly regions is not attempted so far. Weed plants that

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Table 1. Plants reported for insecticidal, growth inhibition and repellent against mosquito vectors.

Plant species (Family)	Plant product	Species tested	Type of activity	References
Tagetes minuta (Compositae)	Essential oil,Whole plant flowers	Anopheles stephensi	Adulticidal	Green et al., 1991
Azadirachta indica (Meliaceae)	Deoiled neem cake powder	Culex spp.Anopheles spp.	Larvicidal, Growth regulator	Rao et al., 1992
Citrus *spp.*(Rutaceae)	Fruit peel oil	Cx.pipens,Cx.quinquefasciatus	Adulticidal, Larvicidal	Mwaiko, 1992
Annona squamosa (Annonaceae	Whole plant extract	Anopheles stephensi	Larvicidal, Growth regulator, Chemosterilant	Saxena et al., 1993
Azadirachta indica (Meliaceae)	Neem oil	Cx.quinquefasciatus, Anopheles stephensi	Larvicidal	Mittal et al., 1993
Azadirachta indica (Meliaceae)	2% Neem oil	An. culicifacies	Repellent	Sharma et al., 1993
Azadirachta indica (Meliaceae)	5-10 % Neem oil	An. culicifacies	Repellent	Sharma et al., 1993
Tagetes minuta (Compositae)	Essential oil,Whole plant flowers	Aedes aegypti	Larvicidal	Tyagi et al ., 1994
Azadirachta indica (Meliaceae)	Deoiled neem cake powder	An.fluviatilis	Repellent	Rajnikant andBhatt, 1994
Citrus *spp.*(Rutaceae)	Fruit peel oil	Cx.pipens,Cx.quinquefasciatus	Adulticidal, Larvicidal	Mwaiko and Saveli, 1994
Cymbopogan spp (Gramineae)	Oil as topical application	An. Culicifacies, Cx.quinquefasciatus	Repellent	Ansari and Razdan, 1995
Azadirachta indica (Meliaceae)	Neem oil-Oil water emulsion on wood scrapping	Aedes aegypti	Anti - pupational	Nagpal et al., 1995
Azadirachta indica (Meliaceae)	5% neem oil in a cream-base topical application	Aedes aegypti	Repellent	Dua et al., 1995
Azadirachta indica (Meliaceae)	Neem oil volatiles	An. Culicifacies, An. stephensi	Oviposition inhibitor	Dhar et al., 1996
Azadirachta indica (Meliaceae)	2% Neem oil mixed with coconut/mustard oil as topical application	Aedes aegypti	Repellent	Sharma et al., 1996
Azadirachta indica (Meliaceae)	5% neem oil in a cream-base topical application	Ae.albopictus	Repellent	Singh et al., 1996
Azadirachta indica (Meliaceae)	1% neem oil in kerosene (Smoke)	An. Culicifacies, An. Annularis , Culex spp.	Repellent	Ansari and Razdan, 1996
Eucalyptus maculate (Myrtaceae)	PMD spray 50% ai based on essential oil	An. Gambiae An. funestus	Repellent	Trigg, 1996
Lantana camara (Verbnaceae)	Flower-Methanol extract + Coconut oil	Ae.albopictus, Ae.aegypti	Repellent	Dua et al., 1996
Artimisia cina (Compositeae)	Aquous extract	Culex pipens	Larvicidal	M.Z.Yali et al., 1996
Cleome droserifolia (Capparidaceae)	Aquous extract	Culex pipens	Larvicidal	M.Z.Yali et al., 1996

Table 1. contd.

Azadirachta indica (Meliaceae)	Neen leaves extract + Malathian	Culex fatigans	Larvicidal	Mohammad Arshad et al., 1996
Polyalthia longifolia (Annonaceae)	Leaf extract	Cx.quinquefasciatus	Larvicidal	Murty et al., 1997
Azadirachta indica (Meliaceae)	Neem oil-Oil water emulsion on wood scrapping	An. stephensi	Larvicidal, Growth regulator	Batra et al., 1998
Mentha piperita (Labiatae)	Essential oil	Cx.quinquefasciatus, An. Stephensi, Ae.aegypti	Larvicidal, Repellent	Ansari et al., 1999
Citrus *spp.*(Rutaceae)	Fruit peel oil	Cx.pipens,Cx.quinquefasciatus	Adulticidal, Larvicidal	Al Dakhil and Morsy., 1999
Tagetes errecta (Compositeae)	Acetone extract, Steam distillated essential oil	Cx.quinquefasciatus, An. Stephensi, Ae.aegypti	Larvicidal,	Pathak et al., 2000
Mentha piperita (Labiatae)	Essential oil	Cx.quinquefasciatus, An. Stephensi, Ae.aegypti	Larvicidal, Repellent	Pathak et al., 2000
Ocimum sanctum (Labiatae)	Steam distillated essential oil	Cx.quinquefasciatus, An. Stephensi, Ae.aegypti	Larvicidal	Pathak et al., 2000
Dalbergia sisco Roxb. (Leguminasae)	Essential oil	Cx.quinquefasciatus, An. Stephensi	Larvicidal, Repellent	Ansari et al., 2000
Azadirachta indica (Meliaceae)	5% neem oil in a cream-base topical	Ae.albopictus, Ae.aegypti, Culex spp	Repellent	Nagpal et al., 2001
Citrus spp.(Rutaceae)	Fruit peel oil	Cx.pipens,Cx.quinquefasciatus	Adulticidal, Larvicidal	Ezenou et al., 2001
Ferronia elephantum (Rutaceae)	Leaves, Methanolic extract	Ae.aegypti	Repellent	Venkatachalam and Jebanesan, 2001
Solanum nigrum Linn. (Solanaceae)	Ethanolic leaf extract	Ae. Caspius, Cx pipiens	Larvicidal, Growth regulator	Ahmed et al., 2001
Azadirachta indica (Meliaceae)	2% Neem oil mixed with coconut/mustard oil as topical application	Ae. darlingi	Repellent	Moore et al., 2002
Solanum nigrum Linn. (Solanaceae)	Crude leaf extract	An. Culicifacies, Cx.quinquefasciatus Ae.aegypti	Larvicidal	Singh et al., 2002
Quillaja saponaria	Plant extract	Ae.aegypti, Cx pipiens	Bio active	Zeev Wiesman, 2003
Atlantia monophylla (Rutaceae)	Methenol extract	Cx.quinquefasciatus Ae.aegypti, Anapheles spp.	Larvicidal & Pupicidal	Sivagnaname et al., 2004
Cinnamomum cassia	Methenol extract	Ae.aegypti	Repellent	Young-cheol Yang et al., 2004
Artomesia orgy, Eucalyptus robusta	Plant extract	Ae.aegypti	Repellent	Gates malaria partnership (2005)
Balanites aegyptiaca	Aqueous extract	Cx pipiens	Larvicidal	Bishnu Chapagain et al., 2005
Azadirachta indica (Meliaceae)	Aqueous extract	An.gambia, Cx.quinquefasciatus	Larvicidal	Obomanu et al., 2006
112 Plants	Medicinal Plant extract	Ae.aegypti	Larvicidal	Suwannee et al., (2006)
Momordica charantia (Cucurbitaceae)	Plant extract	Cx.quinquefasciatus Ae.aegypti, Anapheles spp.	Larvicidal	Singh et al (2006)

grow in large numbers in a vast area makes such areas uncultivable as well as unsuitable as a fodder for the cattle. A number of such weed plants growing in vast areas is observed on the hilly region of the Nilgiris district of Tamil Nadu. A detailed study on the larvicidal properties of the extracts of those weed plants, while providing a chance of mass eradication of mosquito larvae, might also help in clearing off those areas of such weed plants providing more land for cultivation as well as for human occupation.

Hence, an attempt is made in the present study to analyze the larvicidal effect of the leaf extract of a vastly grown (in the hilly region of the Nilgiris district, Tamil Nadu, India) weed plant, *Ageratina adenophora* (Spreng), on two important mosquito species, *A. aegypti* (L) and *Culex quinquefasciatus* (Say).

Figure 1. Photograph showing a thick shrub of *Ageratina adenophora*.

MATERIAL AND METHODS

Selection of plant

A. adenophora (Spreng), (Order: Asterales; Family: Asteraceae) is a weed plant widely found in the hilly region of the Nilgiris District, Tamil Nadu, India. The vernacular Badaga (a native people of the Nilgiris District of Tamil Nadu, India) name for *A. adenophora* is "Nadangichi". *A. adenophora* is a native plant of Mexico (South America) where it is commonly known as "Eupatory". It is also popularly known as "Mexico devil" because of its toxic nature. From Mexico, it was introduced to many part of the world as an ornamental plant during the 19th century and it is now an established pest (weed) in many tropical and sub-tropical countries, especially India, Nigeria, South East Asia, The Pacific Island, South Africa, New Zealand and Australia. *A. adenophora* is a fast spreading plant and its spread was so fast that in some areas, farmers abandoned their holdings (Everist, 1959; Dodd, 1961).

The weed plant *A. adenophora* is observed to grow in vast areas of waste lands in different region in and around Uthagamandalam (The Nilgiris district of Tamil Nadu, India) (Figure 1). *A. adenophora* is known to reproduce by prolific asexual seed production and spreads by dispersal of seeds (Muniyappan and Viraktamath, 1993). Seeds are easily dispersed by wind and water because of their pappus of hairs. This plant is reported to reduce growth of nearby vegetation by releasing inhibitors, perhaps allelopathic compounds into the soil and thus *A. adenophora* is potentially a problem weed in forestry (Morris, 1989). As the plant is known to be a vertebrate poison, particularly for mammals, it is not preferred by the grazing cattle in the hilly regions in and around Udhaga-mandalam (The Nilgiris District, Tamil Nadu, India).

Selection of mosquito species

Two important vector species of mosquitoes such as *A. aegypti* (L) and *C. quinquefasciatus* (Say) are selected for the present study. *A. aegypti* is the principal vector of dengue fever and dengue haemorrhagic fever and it is reported to infect more than hundred million people every year in more than 110 countries in the tropics (Halstead, 2000). *C. quinquefasciatus* is the vector of West Nile Virus which causes encephalitis or meningitis which is known to affect the brain tissue, finally resulting in permanent neurological damage (Hubalek and Halouzka, 1999).

Preparation of leaf extract of *A. adenophora*

Twigs of the weed plant *A. adenophora* (Spreng) (Plate 2) were collected from Mulligoor Village near Udhagamandalam, the Nilgiris District, Tamil Nadu, and brought to the laboratory. The separated leaves (from the twig) were dried under shade at room temperature (29 ± 1°C) for about 20 days. The completely dried leaves were powdered and sieved to get fine powder of leaf. The acetone-leaf extract from the sieved fine leaf powder was obtained by using Soxhlet apparatus.

Two hundred and fifty grams of leaf powder was dissolved in 200 ml of acetone (as a solvent) and extracted in the Soxhlet apparatus for 8 h over a mantle heater at 55°C. The acetone extract was concentrated using a vacuum evaporator at 45°C under low pressure. After complete evaporation of the solvent, the concentrated extract was collected and stored in a refrigerator for later use.

Preparation of stock solution and different concentrations of leaf extract

One gram of the concentrated extract of dried leaves of *A. adenophora* was dissolved in 100 ml of acetone and kept as stock (10 mg/ml) solution. This stock solution was used to prepare the desired concentrations of the extract for exposure of the mosquito larvae.

Procurement of eggs and rearing of mosquito larvae

The eggs of *A. aegypti* and *C. quinquefasciatus* were procured from the Research Laboratory of Indian Centre of Communicable Diseases at Mattupalayam, Coimbatore District. The eggs of *A. aegypti* were obtained as egg rafts on a filter paper whereas, those of *C. quinquefasciatus* obtained as water-dispersed samples. The egg rafts of *A. aegypti* were brought to the laboratory and kept in a tray containing tap water (as culture medium) at laboratory conditions (29 ± 1°C). On the next day, the eggs were observed to hatch out into first instar larvae. Appropriate amount of nutrients (yeast powder and glucose) were added to the culture medium. On the third day after hatching, the first instar larvae moulted into second instar larvae. On the fifth day, third instar larvae were observed which moulted into fourth instar larvae on the seventh day.

The water dispersed eggs of *C. quinquefasciatus*, (obtained from Mattupalayam) were released into tap water (as culture media) in a

Table 2. Larval mortality percentage of 4th instar larvae of *Aedes aegypti* exposed for 24 hours to different concentrations of leaf extract of *Ageratina adenaphora*.

Experimental concentrations in PPM											
Parameter	Control	50	100	150	200	250	300	350	400	450	500
Larval Mortality Percentage	0	0	0	20	30	40	40	40	50	70	70

Table 3. Larval mortality percentage of 4th instar larva of *Culex quinquefasciatus* exposed for 24 hours to different concentrations for of leaf extract of *Ageratina adenaphora*.

Experimental concentrations in PPM											
Parameter	Control	50	100	150	200	250	300	350	400	450	500
Larval Mortality Percentage	0	0	20	30	50	50	60	70	100	100	100

Table 4. 24_{hrs} Lc_{50} values (ppm) and their 95% fiducial (upper and lower) limits, regression equation and Chi-square (X^2) values leaf extract of *Aegeratina adenophora* for the 4th instar larvae of *Aedes aegypti* and *Culex quinquefasciatus*

Species	Lc_{50}	L.F.L	U.F.L	Regression Equation	Calculated X^2 value	Table X^2 value at (0.05)(n-2)df
Aedes aegypti	356.70	319.52	397.12	Y= -0.81 + 2.27 X	1.03	16.919
Culex quinquefaciatus	227.20	203.49	252.92	Y= -0.76 + 2.44 X	0.26	16.919

tray on the same day at laboratory conditions (29 ± 1°C). These eggs were observed to hatch into first instar larvae in the next day itself. The culture medium was enriched with nutrients as mentioned above. The durations of first to fourth instar larval periods of *C. quinquefasciatus* were observed to be similar to that of *A. aegypti*. The fourth instar larvae which moulted on the seventh day were allowed to grow in the medium up to eighth day. The fourth instar larvae of both *A. aegypti* and *C. quinquefasciatus* were used for treatment experiments in the present study.

Treatment of larvae with leaf extract

In the present study, for treatment of larvae with the leaf extract of *A. adenophora*, 100 ml of tap water was kept in a series of glass beakers (of 200 ml capacity). Required quantity of stock solution (containing 10 mg/ml) was added into each beaker (containing 100 ml of tap water) to obtain a particular concentration of the extract. Control medium was also maintained with 100 ml of tap water added with the maximum quantity of acetone present in the stock solution of the extract. Separate series of exposure medium with desired concentrations of extract were kept for *A. aegypti* and *C. quinquefasciatus*. The larval mortality of fourth instar larvae of *A. aegypti* and *C. quinquefasciatus* were observed separately in control, 50, 100, 150, 200, 250, 300, 350, 400, 450 and 500 ppm concentrations of the leaf extract of *A. adenophora*. Twenty numbers of 4th instar larvae of both *A. aegypti* and *C. quinquefas-ciatus* were separately introduced into control and different concentrations of leaf extract. The number of larvae surviving at the end of 24 h was recorded and the per cent mortality values were calculated. Based on the per cent mortality values, Lc_{50} value of leaf extract of *A. adenophora* for *A. aegypti* and *C. quinquefasciatus* were obtained separately by calculating the regression line employing Probit analysis of Finney, (1964) as described by Busvine, (1971).

Calculation of regression line

The effect of leaf extract of *A. adenophera* on the mortality of the 4th instar larvae (of *A. aegypti* and *C. quinquefasciatus*) following 24 h were corrected for natural response by Abbott's formula (Abbott, 1925) as follows: Corrected % kill = (Proportion of test mortality - Proportion of control mortality) / (1 - Proportion of control mortality) x 100. Busvine (1971) suggested that the critical doses of susceptibility can be estimated with sufficient accuracy from a probit/log concentration graph. Based on the log concentration and the probit mortality percentage values, regression equation was obtained. Using the regression equation, a straight line was fitted. Fitting of regression line and homogeneity of population were also tested employing Chi-square (X^2) test (Busvine, 1971). By graphical interpolation, Lc_{50} (median lethal concentration) values of the leaf extract of *A. adenophora* for 24 h of exposure of 4th instar larvae (of *A. aegypti* and *C. quinquefasciatus*) and their fiducial limits (95% upper fiducial limit and lower fiducial limit) were calculated.

RESULTS AND DISCUSSION

The percent mortality values of 4th instar larvae treated with different concentration (ranging from 50 to 500 ppm) of the leaf extract of *A. adenophora* at the end of 24 h are represented Table 2 for *A. aegypti* and those for *C. quinquefasciatus* in Table 3. The regression equations (based on Probit analysis) between the concentration of leaf extract and 24 h per cent mortality of 4th instar larvae of *A. aegypti* and of *C. quinquefasciatus* are represented in Figures 2 and 3, respectively. The Lc_{50} values and their 95% upper and lower fiducial limits, regression equations and Chi-square (X^2) values of the leaf extract of *A. adenophora* for 24 h of exposure of *A. aegypti* and *C. quinquefasciatus* are given in Table 4. Based on the Probit analysis, the 24 h Lc_{50} value of the leaf extract of *A. adenophora* for *A. aegypti* was found to 356.70 ppm and that for *C. quinquefasciatus* was found to be 227.20 ppm (Table 4). Table 5 provides information (based on previous works) of Lc_{50} values of different types of plant

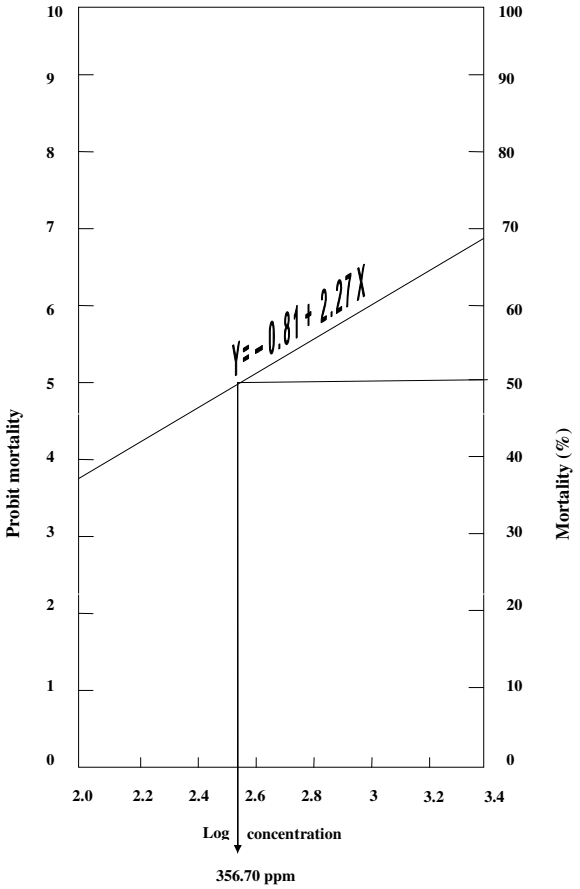

Figure 2. Regression line (based on Probit analysis) of log concentration of leaf extract of *Ageratina adenaphora* vs. per cent mortality of 4th instar larvae of *Aedes aegypti*.

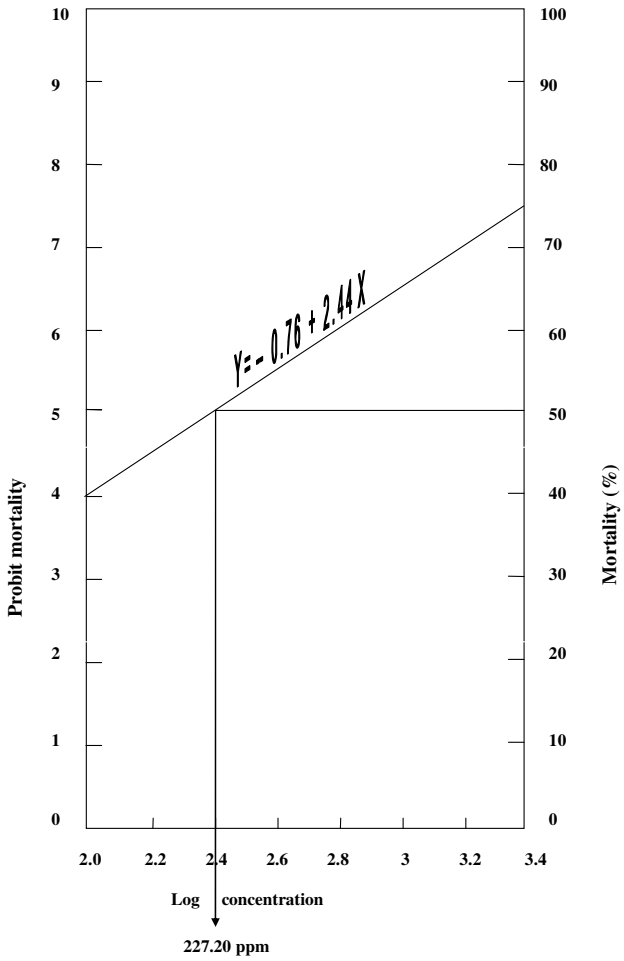

Figure 3. Regression line (based on Probit analysis) of log concentration of leaf extract of *Ageratina adenaphora* vs. per cent mortality of 4th instar larvae of *Culex quinquefasciatus*.

extracts on different species of mosquitoes, besides the data from the present investigation on *A. aegypti* and *C. quinquefasciatus.*

Since the discovery of DDT, control of disease-causing mosquito species has been almost completely based on synthetic organic insecticides. Following DDT, conventional pesticides such as malathion and pyrithroids are generally used for mosquito control. But the extensive use of synthetic organic insecticides during the last five decades has resulted in environmental hazards. Besides, this also caused the development of physiological resistance in the major vector species. This has necessitated the need for search and development of environmentally safe, biodegradable, low cost and indigenous methods for vector control, which can be used with minimum care by individual and communities in specific situation (ICMR bulletin, 2003).

The control of mosquito-borne diseases can be achieved either by killing, preventing mosquitoes to bite human beings (by using repellents) or by causing larval mortality in a large scale at the breeding centres of the vectors in the environment. A survey of literature on control of different species of mosquito revealed that assessment of the efficacy of different phytochemicals obtained from various plants has been carried out by a number of researches on the field of vector control. Sukumar et al. (1991) made an extensive review of botanical derivatives in mosquito control. A large number of plant extracts have been reported to have mosquitocidal or repellent activities against mosquito vectors, but very few plant products have shown practical utility for mosquito control (Sukumar et al., 1991). The plant products can be obtained either from the whole plant or from a specific part by extraction with different types of solvents such as aqueous, methanol, chloroform and hexane, depending on the polarity of the phytochemicals (Table 1). It could also be conceived from the review that some phytochemicals act as general toxicants both against adult as well as against larval stages of mosquitoes, while others interfere with growth and development (growth inhibitors) or with reproduction (chemosterilent) or produce olfactory stimuli acting as repellent or attractant.

Table 5. 24 $_{hrs}$ Lc_{50} (median lethal concentration)value of some plant extracts for different mosquito species based of larvicidal activity

Species	Plant	Extract	24 hrs value	Author
Culex fatigans	Neem	Leaf extract	390 ppm	Mohammad Arshad et al., 1996.
Culex quinquefasciatus	*C.reticulata*	Seed + Abacunone	6.31 ppm	ICMR Bulletin (2003)
Culex quinquefasciatus	*C.reticulata*	Seed + Nomilon	26.61 ppm	ICMR Bulletin (2003)
Culex quinquefasciatus	*C.reticulata*	Seed + Lumonin	59.51 ppm	ICMR Bulletin (2003)
Aedes aegypti	*Quillaja sapanin*	Plant extract	500 mg/l	Zeev Wiesman and Bishnu, 2003
Culex pipens	*Quillaja sapanin*	Plant extract	500 mg/l	Zeev Wiesman and Bishnu, 2003
Culex quinquefasciatus	*Atlanda monophylla*	Plant + extract	23.4 mg/l	Sivagnaname Kalyanasundarm, 2004
Anapheles stepensi	*Atlanda monophylla*	Plant extract	21.3 mg/l	Sivagnaname Kalyanasundarm, 2004
Aedes aegypti	*Atlanda monophylla*	Plant extract	5.7 mg/l	Sivagnaname Kalyanasundarm, 2004.
Culex pipiens	*Balanities aegyptiaca*	Kernel extract	2.0 %	Bishnu and Zeev Wiesman, 2005
Culex pipens	*Balanities aegyptiaca*	Root extract	2.0 %	Bishnu and Zeev Wiesman, 2005
Culex pipens	*Balanities aegyptiaca*	Berk extract	2.0 %	Bishnu and Zeev Wiesman, 2005
Anopheles stephensi	*Momordica charantia*	Crude fruit extract	0.50 %	Singh et al.,2006
Culex quinquefasciatus	*Momordica charantia*	Crude fruit extract	1.29 %	Singh et al., 2006
Aedes aegypti	*Momordica charantia*	Crude fruit extract	1.45 %	Singh et al., 2006
Aedes aegypti	*Ageratina adenophora*	Leaf extract	345.34 ppm	Present study
Culex quinquefasciatus	*Ageratina adenophora*	Leaf extract	227.19 ppm	Present study

The most commonly studied plant for control of mosquito is *Azadirachta indica* which is commonly known as neem in India. Neem contains at least 35 biologically active principles of which azadirachtin (AZA), a triterpenoid is the predominant active insecticidal ingredient in the seeds, leaves, and other parts of the tree (Mulla and Su, 1999). A comparison of 24 h Lc_{50} values of different plant products against mosquito larvae would provide some information on the efficacy of the product against mosquito control. A perusal of (Table 5) of Lc_{50} values (in terms of ppm) of different plant extracts clearly indicate that the leaf extract of *A. adenophora* is more toxic to both *A. aegypti* and *C. quinquefasciatus* (in the present study) when compared to that of leaf extract of neem exposed to *Culex fatigans*. This higher larvicidal effect (showing lesser Lc_{50} values compared to neem leaf extract) (Table 5) could be taken to suggest that the leaf extract of *A. adenophora* could be effectively used for the control of mosquito larvae in public health operations. The separation and identification of the different chemical compounds of the leaf extract of *A. adenophora* is now in progress in the laboratory.

The weed plant *A. adenophora* is observed to grow in vast areas in and around Mulligoor village and different parts of the hilly region of Nilgiri district. Since this plant is reported to be a repellent for cattle, enormous growth of this plant makes the region unavailable for agricultural and residential purposes. Collection of large quantities of leaf sample (either by collecting individual twigs or by totally uprooting the plant) could be used to obtain large quantities of the leaf extract. The extract could be used for spraying in stagnant water bodies which are known to be the breeding grounds for mosquitoes acting as vector for a multitude of infectious diseases. Collection of leaves and field spraying of the leaf extract of *A. adenophora* is now carried out (in and around Coimbatore City) under this project in order to establish the efficacy of the plant extract as an effective larvicidal agent for the mosquito control.

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