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# Laboratory Evaluation of Two Meliaceae Species as Larvicides Against *Culex quinquefasciatus* Say (Diptera: Culicidae)

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## Abstract

Mosquitoes present a key threat to millions of people worldwide, since they are vectors for dangerous pathogens and parasites of diseases such as malaria, filariasis, yellow fever, dengue, chikungunya and Zika virus disease. *Culex quinquefasciatus* is the principal vector of bancroftian filariasis and also a potential vector of several arboviruses like West Nile virus (WNV) and Rift Valley fever virus. To prevent proliferation of mosquito-borne diseases and to improve quality of environment and public health, mosquito control is essential. Plants enriched with phytochemicals are reported to possess insecticidal properties particularly mosquitocidal. Therefore, in the present study, the larvicidal efficacy of crude petroleum ether, chloroform, ethyl acetate and methanol leaf extracts of *Melia dubia* and *Swietenia mahagoni* against *Culex quinquefasciatus* was studied at concentrations of 62.5, 125, 250, 500 and 1000 mg/L. Larval mortality was assessed 24, 48 and 72 hours after treatment. The results revealed that the petroleum ether leaf extract of *Melia dubia* and *Swietenia mahagoni* showed the highest larvicidal activity than the other extracts. One hundred per cent larval mortality was observed in petroleum ether extract of both plants at 500 mg/L after 48 hours. The $LC_{50}$ values of crude petroleum ether leaf extract was 380.11 and 80.31; 70.51 and 52.70 mg/L after 24 and 48 hours, respectively. Among the two plant species tested, *Swietenia mahagoni* was found to show higher activity as its $LC_{50}$ value was five times less than the $LC_{50}$ value of *Melia dubia* after 24 hours treatment. Further investigations are needed to elucidate this activity against a wide range of all stages of mosquito species and also the active ingredient(s) of the extract responsible for larvicidal activity should be identified

**Keywords**

*Melia dubia*; *Swietenia mahagoni*; Crude leaf extracts; Larvicidal efficacy; *Culex quinquefasciatus*

## Introduction

Arthropods are dangerous vectors of deadly pathogens and parasites, which may spread as epidemics or pandemics in the increasing world population of humans and animals [1,2]. In particular, mosquitoes (Diptera: Culicidae) present an immense threat to millions of people worldwide, since they act as vectors for devastating pathogens and parasites, including malaria, filariasis, yellow fever, dengue, chikungunya and Zika virus disease [3,4]. *Culex* mosquito is probably the most abundant house mosquito in towns and cities of the tropical countries. *Culex* mosquitoes develop in standing water such as polluted ponds, marshes, tanks, street gutters, tin cans, barrels, ornamental ponds, puddles, creeks, ditches, etc [5]. The Southern house mosquito, *Culex quinquefasciatus* acts as an important "urban bridge vector" which bridges different reservoir/amplifier hosts to humans because of its encounter with different vertebrates. It also creates an ecological bridge between urban, periurban and rural areas owing to its presence and adaptability in diverse ecological niches. They emerged as a smart vector because of the adaptive fitness, ecological plasticity, invasive behaviour, host specificity and high reproductive potential along with expanded immune gene repertoire property at the genetic level. This mosquito possesses the necessary potential to initiate and facilitate the disease transmission by establishing an effective vector-host transmission cycle for diverse pathogens in different environments [6]. A wide variety of sites, mostly characterized by coloured, foul water with high nutrient values and low dissolved oxygen content, such as pumping and irrigation wells, canals, wastewater treatment ponds, sewage overflows, rain pools, rice paddy fields, fish ponds, septic tanks, drains, cesspools, agricultural trenches, vegetable farms, etc. generally are preferred as the breeding sites by this mosquito [7,8]. *Culex quinquefasciatus* is the principal vector of bancroftian filariasis and a potential vector of *Dirofilaria immitis* [9,10], West Nile virus (WNV) [11] and Rift Valley fever virus, avian pox and protozoa like *Plasmodium relictum* that causes bird malaria [6]. Additionally, it can transmit Japanese Encephalitis virus (JEV) [12], St. Louis Encephalitis virus (SLEV) [13], Reticulo endotheliosis virus [14], Murray Valley encephalitis [15], Reovirus Type 3 and Chikungunya virus [14,16]. Thus, evidently this cosmopolitan mosquito is a potential vector of many important pathogens causing concern to public health.

To prevent proliferation of mosquito-borne diseases and to improve quality of environment and public health, mosquito control is essential. In this scenario, vector control is a crucial prevention tool. The use of synthetic pesticides began in the 1930's and became widespread after World War II. Ever since, mosquito control has relied upon synthetic insecticides with very few different types being discovered in terms of mode of action and targeted receptors. These products have been a continuing source of concern due to the emergence of widespread resistance in targeted species, effects on non-target species, human health and issues associated with environmental persistence and bioaccumulation. It has prompted researchers to look for alternative approaches ranging from provision of or promoting the adoption of effective and transparent mosquito management strategies that focus on monitoring and surveillance, source reduction and environment friendly least-toxic larval control. These factors have resulted in an urge to look for environment friendly, biodegradable and target specific insecticides against mosquito species [17]. India is a varietal emporium of endemic and exotic flora enriched with phytochemicals having pharmacognostical and toxicological properties. The toxicological properties of phytochemicals reflect the potential of plants as a source of insecticidal agents. Prospection for new larvicidal molecules based on rich plant

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biodiversity is appreciable as compounds of plant derivatives are safer to use and leaves no residue in the environment [18]. In the current era, research is focused on natural products to combat these disease transmitting vectors and a recent emphasis has been placed on plant material and various reports on the use of natural plant products against mosquito vectors have been documented [19-33]. Therefore, in the present study, the crude leaf extracts of two plant species, *Melia dubia* and *Swietenia mahagoni* belonging to Meliaceae family were tested for their larvicidal efficacy against *Culex quinquefasciatus*.

*Melia dubia* Cav. is commonly known as Pride of India in English [34] and 'malaivembu' in Tamil [35]. It is also called mahaneem or forest neem, which is a tree species of India, Sri Lanka, Malaysia, Australia and Angola [36]. The plant has been used in folk remedies for pain and inflammation [37]. Every part of this plant is being used in traditional herbal medicine including treatment of leprosy, eczema, asthma, malaria, fever, venereal disease [38], ascariasis and pain [39]. The fruits of *Melia dubia* are used as an anthelminthic, astringent and also in the treatment of colic disorders [40]. The plant possess antiviral [41], antidepressant [42], cytotoxic [43], antimalarial [44], antibacterial [35], antifungal, anticancer [45,46] and hypoglycemic activity [47]. *Melia dubia* possess phytochemical constituents *viz.*, alkaloids, carbohydrates, steroids, tannins, flavonoids, saponins, glycosides [48], monoterpenes, sesquiterpenes [49], unsaturated fatty acids, terpenoids, phenolic derivatives [50] and limonoids [51]. Besides these, some of the phytocompounds extracted from *Melia dubia* are compositin, composidolide [47,52] and salannine [37]. The extracts of *Melia dubia* are reported to possess growth inhibiting activity, stomach poison, moulting disorders, morphogenetic defects and antifeedant property against insect pests [53]. The plant is reported to be toxic to *Spodoptera litura* and *Helicoverpa armigera* [54,55]. Further, the crude leaf extracts of *Melia dubia* has been tested for insecticidal activity against the larvae of *Anopheles stephensi* [56] *Culex quinquefasciatus* [34,35,57,58] and *Aedes aegypti* [59].

*Swietenia mahagoni* (L.) Jacq is indigenous to the southern regions of Florida, Cuba, Jamaica and the islands of Hispaniola [60]. *Swietenia mahagoni* commonly known as 'West Indian mahagony' in English and 'mahagony' in Tamil [61] functions as an antidiarrhoeal in the Indian system of medicine [62]. The decoction of this leaf is used to treat nerve disorders, while the infusion of the seed, is used to relieve chest pain [63]. The seeds also have a potential in controlling amoebiasis, cough and intestinal parasitism [64]. The seed oil is used as an ointment for skin cuts, itches and wounds to ameliorate the healing process and *Swietenia mahagoni* is reported to have medicinal value for treatment of hypertension, diabetes and malaria [60]. *Swietenia mahagoni* possess antifungal [65], antibacterial [66], antimicrobial [60,67], cytotoxic [68], hypoglycemic, antioxidant [69], gastroprotective [60] and antidepressant properties [70]. The phytochemical constituents include saponins, glycosides, terpenoids, alkaloids, tannins, flavonoids [60], anthraquinones, volatile oils [65], carbohydrates, proteins and amino acids [71] and some of the phytocompounds extracted include cyclomahogenol [72], swietenolide and 2-hydroxy-3-o-tigloyl swietenoide [73]. *Swietenia mahagoni* possesses insecticidal activity as the leaf extracts showed antifeedant property against the red flour beetle, *Tribolium castaneum* [74], larvicidal efficacy against *Culex quinquefasciatus* [75-77] and repellent effect against *Culex quinquefasciatus* [77] and *Anopheles stephensi* [78].

## Materials and Methods

### Plant collection and extraction

Mature fresh and healthy leaves of *Melia dubia* and *Swietenia mahagoni* collected from Chennai, Tamil Nadu, India, were brought to the laboratory. Taxonomical identity was confirmed at the Department of Plant Biology and Plant Biotechnology, Madras Christian College, Chennai, Tamil Nadu, India. The leaves were washed with dechlorinated tap water and shade dried at room temperature. Dried leaves of *Melia dubia* were powdered with the aid of an electric blender. The powdered leaves (1 Kg) were sequentially extracted with 3 L of solvents each *viz.*, petroleum ether, chloroform, ethyl acetate and methanol using a Soxhlet apparatus [79]. The crude leaf extracts were filtered through a Buchner funnel with Whatman number 1 filter paper and were then evaporated to dryness in a rotary vacuum evaporator to obtain crude petroleum ether, chloroform, ethyl acetate and methanol extracts of *Melia dubia* leaves. Likewise, the same methodology was adopted to obtain the crude petroleum ether, chloroform, ethyl acetate and methanol leaf extracts of *Swietenia mahagoni*. One per cent stock solution from the crude extracts of each plant was prepared by adding adequate volume of acetone and was refrigerated at 4°C until testing for larvicidal bioassay.

### Test mosquitoes

*Culex* immature collected from various places in Chennai, Tamil Nadu, India was transported to the laboratory where, the immature mosquitoes were transferred to enamel larval trays until adult emergence. After emergence, the adult mosquitoes were identified up to species level and confirmed before rearing. Cyclic generations of *Culex quinquefasciatus* were maintained separately in mosquito cages (2'*x*2'*x*2') in an insectary with a mean room temperature of 27 ± 2°C and a relative humidity of 70-80%. The adult mosquitoes were fed on ten per cent glucose solution in water. The eggs laid were then transferred to enamel larval trays maintained in the larval rearing chamber. The larvae were fed with larval food (dog biscuits and yeast in the ratio 3:1). The larvae on becoming pupae were collected, transferred to plastic bowls and kept inside a mosquito cage for adult emergence.

### Larvicidal bioassay

Standard WHO [80] protocol with minor modifications was adopted for the study. The tests were conducted in glass beakers. *Culex quinquefasciatus* immature particularly early third instar larvae from laboratory colonized mosquitoes of $F_1$ generation were used for the study. Larvicidal activity at test concentrations of 62.5, 125, 250, 500 and 1000 mg/L of each crude leaf extracts was assessed. The required test concentrations and quantity of test solution was prepared by serially diluting one per cent stock solution of each crude extract. Twenty healthy larvae were released into each 250 mL glass beaker containing 200 mL of water and test concentration. Mortality was observed 24, 48 and 72 hours after treatment. A total of three trials with three replicates per trial for each concentration were carried out. Controls were run simultaneously. Treated control was prepared by the addition of acetone to distilled water. Distilled water served as untreated control. The larval per cent mortality was calculated and when larval control mortality ranged from 5-20% it was corrected using Abbott's [81] formula.

### Statistical analysis

Data from all replicates were pooled for statistical analysis.

$LC_{50}$ and $LC_{90}$ values were calculated using SPSS software by probit analysis [82]. ANOVA was performed to determine the difference in larval mortality between concentrations. Results with $P<0.05$ level were considered to be statistically significant.

## Results

The results revealed that the petroleum ether crude leaf extract of *Melia dubia* exhibited the highest larvicidal activity against *Culex quinquefasciatus* followed by ethyl acetate and chloroform after 24 hours (Figure 1). One hundred per cent larval mortality was observed in petroleum ether extract at 500 mg/L at 48 and 72 hours (Table 1, Figures 2 & 3). The $LC_{50}$ value of crude petroleum ether leaf extract was 380.11, 102.07 and 80.31 mg/L after 24, 48 and 72 hours, respectively (Table 2). In the case of *Swietenia mahagoni*, the same trend was observed as the crude petroleum ether leaf extract exhibited the highest larval mortality against *Culex quinquefasciatus* (Figure 4-9). One hundred per cent mortality was also observed in petroleum ether extract at 500 mg/L at 48 and 72 hours (Table 3 and Figures 5 and 6). The $LC_{50}$ values were 70.51, 52.70 and 26.96 mg/L after 24, 48 and 72 hours, respectively (Table 2 and Figures 10-12). Among the two plant species tested, *Swietenia mahagoni* was found to show higher activity as its $LC_{50}$ value was five times less than the $LC_{50}$ value of *Melia dubia* after 24 hours treatment.

## Discussion

The field of biodiscovery and plant based pesticides steadily progresses and the development of botanical insecticides have become more rigorous in recent years with calls for more standardization [83]. In recent years, a large number of botanical products, including plant extracts, essential oils, and pure metabolites, have been proposed for eco-friendly control of mosquito vectors and other blood-sucking arthropods [84-87]. Mosquito larvae live in a wide variety of aquatic environments, which makes them attractive targets for insecticides. It is easier to control them when they occur as juveniles in concentrated and contained habitats as compared to when they are in a widely dispersed adult population [19]. In the present study, the larvicidal activity of *Melia dubia* and *Swietenia mahagoni* crude leaf extracts were studied against *Culex quinquefasciatus*. The crude petroleum ether extract of both the plants were found to be effective and $LC_{50}$ values were 380.11 and 70.51 mg/L after 24 hours, followed by ethyl acetate whose $LC_{50}$ values were 551.08 and 178.05 mg/L, respectively. However, among the two plant species tested, *Swietenia mahagoni* was found to show higher activity than *Melia dubia*. Pavela [88] reported the methanolic stem extract of *Artemisia campestris* to exhibit larvicidal activity against *Culex quinquefasciatus* with $LC_{50}$ value of 23.0 ppm. The ethanolic extract of aerial parts of *Vernonia amnophila* showed larvicidal activity against *Aedes fluviatilis* with $LC_{50}$ value of 40.0 ppm [89]. The methanolic extract of *Gleoonis coronarium* flowers ($LC_{50}$ 53.0 ppm), *Sonchus arvensis* stem ($LC_{50}$ 68.0 ppm), *Matricaria maritima* flowers ($LC_{50}$ 72.0 ppm) [90] and *Tagetes erecta* petroleum ether leaf extract ($LC_{50}$ 100.0 pm) [91] exhibited larvicidal activity against *Culex quinquefasciatus*. Crude extracts of plants which showed larvicidal activity with $LC_{50}$ value of 100 ppm (mg/L) and above against *Culex quinquefasciatus* are the methanolic extracts of *Achilea millefolium* stem ($LC_{50}$ 120.0 ppm), *Tanacetum vulgare* flowers ($LC_{50}$ 178.0 ppm) and *Otanthus maritimus* stem ($LC_{50}$ value of 195.0 ppm) [88].

Members belonging to Meliaceae family have been reported to possess larvicidal activity [92-94]. Mwangi and Mukiama [95] observed *Melia volkensi* fruit kernel extracts to have acute toxic effects on the mosquito larvae. Coria [96] reported the crude leaf extracts of *Melia azedarach* to be toxic against *Aedes aegypti* larvae and $LC_{50}$ was 0.76 g/L at 96 hours. *Melia azedarach* crude aqueous extracts of fruit, leaf and bark showed activity with $LC_{50}$ values of 2035.13, 612.25 and 368.30 ppm respectively [97], its acetone leaf extract showed $LC_{50}$ of 305.20 ppm against *Culex quinquefasciatus* [98] and methanolic crude fruit extracts exhibited $LC_{50}$ value of 169.48 ppm against *Culex pipiens* [99]. As expected, the larvicidal activity varies considerably according to the species of mosquito and the plant/ plant part used. In order to get a potent extract, the solvents should be chosen with a thorough understanding and knowledge based on the phytochemical profile of the plant/ plant part used as there exists a relationship between the extract effectiveness and solvent polarity [92]. The results of the present study were comparable with the earlier reports of *Melia dubia* and *Swietenia mahagoni* against the larvae of *Culex quinquefasciatus* in view of the aforementioned factors. Chanthuru [57] showed that the crude ethyl acetate extract of *Melia dubia* leaf and root exhibited 98.0 and 96.0% larval mortality. Deepa [59] indicated the crude methanol leaf extract of *Melia dubia* to display larvicidal activity against *Aedes aegypti* with $LC_{50}$ of 100.12 ppm. However, Sakthivadivel [34] reported that the crude petroleum ether leaf extract of *Melia dubia* did not show any larvicidal activity at 1000 ppm. On the other hand, the crude petroleum ether leaf extract of *Swietenia mahagoni* exhibited 13.97 ppm after 24 hours of exposure [77].

When it comes to comparing the results from different studies, in addition to keeping extraction methods identical, other biological factors must be taken into account [83]. The usage of phytochemicals against mosquito larvae can vary remarkably depending on plant species, plant parts used, age of plant parts (young, mature or senescent) and solvents used explained the existence of variations in the level of effectiveness of phytochemical compounds on target mosquito species vis-à-vis plant parts from which these were extracted, responses in species and their developmental stages against the specified extract, solvent of extraction, geographical origin of the plant, photosensitivity of some of the compounds in the extract, effect on growth and reproduction [27]. Changes in the larvicidal efficacy of the plant extracts occurs due to geographical origin of the plant as in *Piper* sp. [100], *Ocimum sanctum*, *Momordica charantia* [101], *Jatropha* sp. [91], *Azadirachta indica* and *Citrus* sp. [102]; due to variation in the species of plant examined in *Cleome* [103],

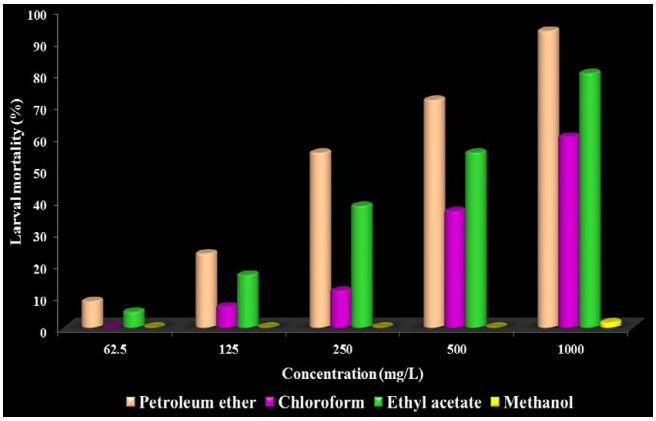


**Figure 1:** Larvicidal activity of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

**Table 1**: Larvicidal efficacy of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus*.

| Hours | Concentration (mg/L) | Petroleum ether | Chloroform | Ethyl acetate | Methanol |
|---|---|---|---|---|---|
| 24 | 62.5 | 1.66 ± 0.57$^{a}$ (8.3) | 0.00 ± 0.00$^{a}$ (0.0) | 1.00 ± 1.00$^{a}$ (5.0) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 4.66 ± 1.52$^{a}$ (23.3) | 1.33 ± 0.57$^{a}$ (6.6) | 3.33 ± 1.52$^{a}$ (16.6) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 250 | 11.00 ± 1.00$^{b}$ (55.0) | 2.33 ± 1.52$^{a}$ (11.6) | 7.66 ± 1.52$^{b}$ (38.3) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 500 | 14.33 ± 1.15$^{c}$ (71.6) | 7.33 ± 2.08$^{b}$ (36.6) | 11.00 ± 1.00$^{b}$ (55.0) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 1000 | 18.66 ± 1.52$^{d}$ (93.3) | 12.00 ± 2.00$^{c}$ (60.0) | 16.00 ± 1.00$^{c}$ (80.0) | 0.33 ± 0.57$^{a}$ (1.6) |
| 48 | 62.5 | 11.33 ± 2.08$^{b}$ (56.5) | 0.33 ± 0.57$^{a}$ (1.6) | 2.33 ± 0.57$^{b}$ (11.6) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 15.00 ± 1.15$^{c}$ (75.0) | 2.33 ± 1.52$^{a}$ (11.6) | 4.00 ± 1.00$^{c}$ (20.0) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 250 | 17.33 ± 1.15$^{d}$ (86.5) | 5.33 ± 1.52$^{b}$ (26.6) | 11.66 ± 1.15$^{d}$ (58.3) | 0.33 ± 0.57$^{a}$ (1.6) |
| | 500 | 20.00 ± 0.00$^{e}$ (100.0) | 11.00 ± 1.73$^{c}$ (55.0) | 13.66 ± 1.52$^{e}$ (68.3) | 3.66 ± 0.57$^{b}$ (18.3) |
| | 1000 | 20.00 ± 0.00$^{e}$ (100.0) | 17.33 ± 2.08$^{d}$ (86.6) | 18.00 ± 1.00$^{f}$ (90.0) | 5.33 ± 0.57$^{c}$ (26.6) |
| 72 | 62.5 | 12.33 ± 2.08$^{b}$ (61.6) | 0.66 ± 0.57$^{a}$ (3.3) | 3.66 ± 0.57$^{b}$ (18.3) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 16.00 ± 1.00$^{c}$ (80.0) | 4.00 ± 1.00$^{b}$ (20.0) | 11.33 ± 2.30$^{c}$ (56.6) | 0.33 ± 0.57$^{a}$ (1.6) |
| | 250 | 19.33 ± 0.57$^{d}$ (96.6) | 9.33 ± 1.52$^{c}$ (46.6) | 15.00 ± 1.00$^{d}$ (75.0) | 1.33 ± 1.52$^{a}$ (6.6) |
| | 500 | 20.00 ± 0.00$^{d}$ (100.0) | 14.33 ± 2.08$^{d}$ (71.6) | 19.00 ± 1.00$^{e}$ (95.0) | 4.33 ± 1.15$^{b}$ (21.6) |
| | 1000 | 20.00 ± 0.00$^{d}$ (100.0) | 19.33 ± 1.15$^{e}$ (96.6) | 19.33 ± 1.15$^{e}$ (96.6) | 7.33 ± 1.52$^{c}$ (36.6) |

Values are mean of three replicates of three trials ± standard deviation. Values in parenthesis denote per cent larval mortality. Different superscript alphabets indicate statistical significant difference in larval mortality between concentrations at $P<0.05$ level by one way ANOVA followed by DMRT.

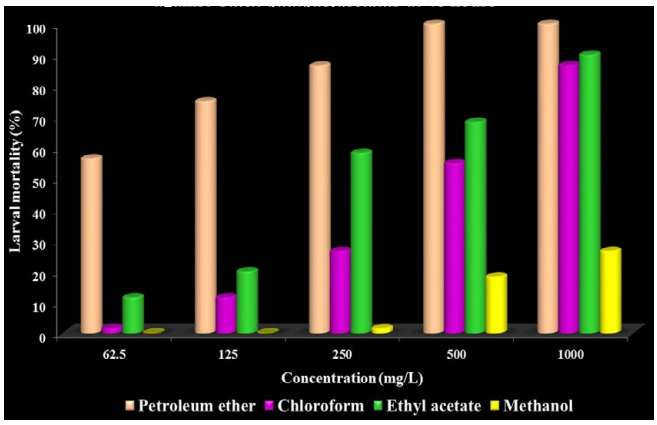


**Figure 2:** Larvicidial activity of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 48 hours.

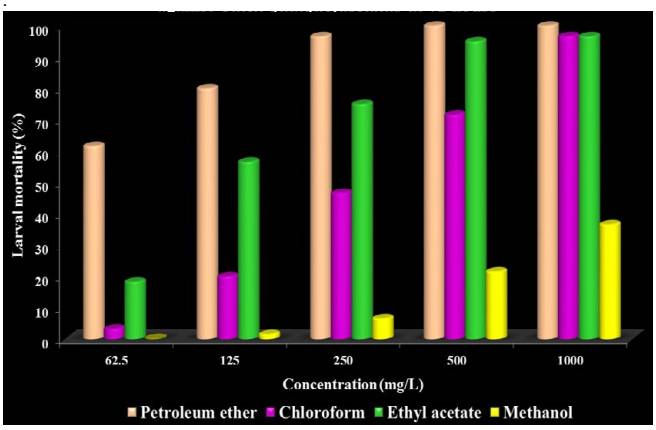


**Figure 3:** Larvicidial activity of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 72 hours.

*Piper* [100], *Eucalyptus*, *Phyllanthus* and *Plumbago* [104], *Euphorbia* [105], *Curcuma* [106], *Annona* [107], *Solanum* [108] and *Vitex* [109]; between plant parts used as in *Solanum xanthocarpum* [110], *Euphorbia tirucalli* [105], *Ocimum sanctum* [111], *Solanum villosum* [112], *Withania somnifera* [91], *Azadirachta indica* [102], *Annona squamosa* and *Moringa oleifera* [107]; variation of the larvicidal potential of the same plant changed with the solvents used as evidenced in the case of *Solanum xanthocarpum* [110], *Euphorbia tirucalli* [105], *Momordica charantia* [101], *Citrullus colocynthis* [91], *Azadirachta indica* [102], *Solanum nigrum* [108] and *Annona squamosa* [113] and likewise, different species of mosquitoes show varied larval mortality as in *Piper retrofractum* [114], *Curcuma domestica* [115], *Cestrum diurnum* [116], *Jatropha curcas* [104], *Citrullus vulgaris* [117], *Withania somnifera* [91] and *Tridax procumbens* [113].

Many plant species have been screened for their larvicidal activity

**Table 2:** Probit analysis of larvicidal efficacy of crude leaf extracts of *Melia dubia* and *Swietenia mahagoni* against *Culex quinquefasciatus*.

| Hours | Petroleum ether | Chloroform | Ethyl acetate | Methanol |
|---|---|---|---|---|
| ***Melia dubia* $LC_{50}$ (mg/L)** | | | | |
| **24** | 380.11 | 806.56 | 551.08 | 1779.79 |
| **48** | 102.07 | 544.07 | 506.02 | 1086.26 |
| **72** | 80.31 | 376.01 | 213.56 | 1086.26 |
| ***Swietenia mahagoni* $LC_{50}$ (mg/L)** | | | | |
| **24** | 70.51 | 466.07 | 178.05 | 698.45 |
| **48** | 52.70 | 228.55 | 131.82 | 698.45 |
| **72** | 26.96 | 159.86 | 67.32 | 698.45 |
| ***Melia dubia* $LC_{90}$ (mg/L)** | | | | |
| **24** | 734.03 | 1333.93 | 1030.23 | 2247.08 |
| **48** | 208.64 | 941.01 | 807.37 | 1716.31 |
| **72** | 151.56 | 672.41 | 466.91 | 1716.31 |
| ***Swietenia mahagoni* $LC_{90}$ (mg/L)** | | | | |
| **24** | 106.79 | 642.92 | 285.21 | 1133.34 |
| **48** | 67.61 | 354.52 | 212.53 | 1133.34 |
| **72** | 34.49 | 248.66 | 85.51 | 1133.34 |

$LC_{50}$: Lethal concentration that kills 50% of the exposed larvae
$LC_{90}$: Lethal concentration that kills 90% of the exposed larvae

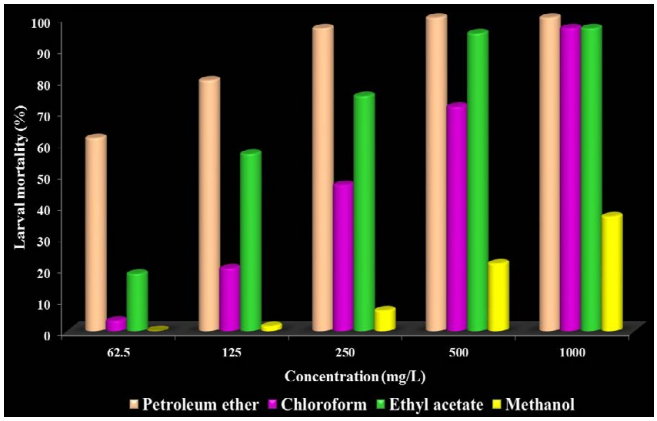


**Figure 4:** Larvicidial activity of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

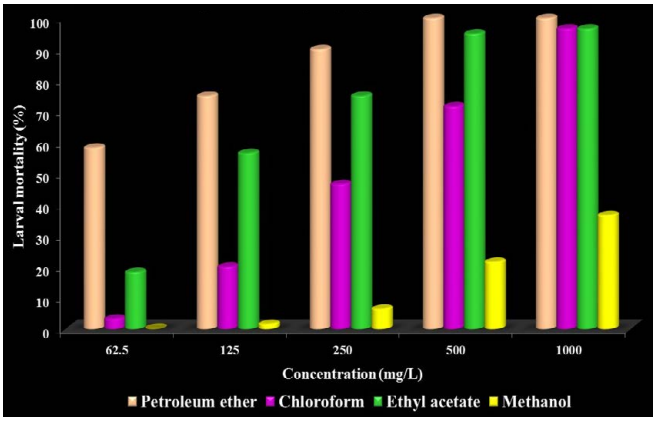


**Figure 6:** Larvicidial activity of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 72hours.

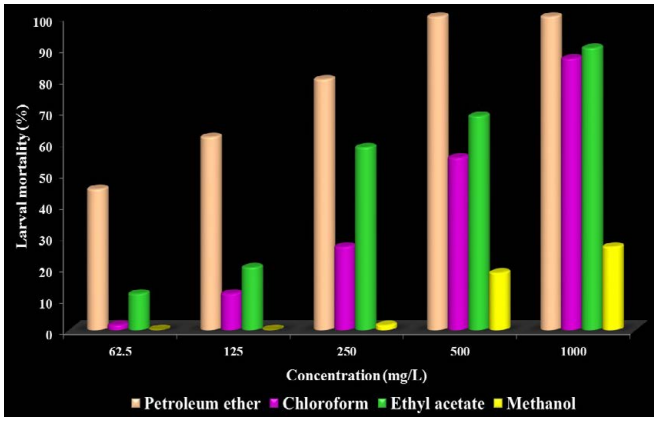


**Figure 5:** Larvicidial activity of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 48 hours.

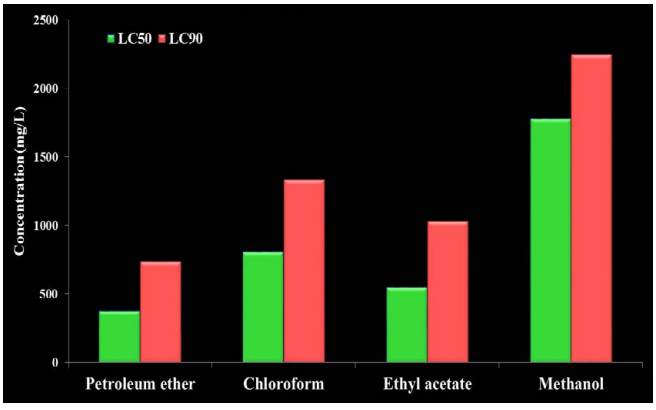


**Figure 7:** Probit analysis of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

**Table 3**: Larvicidal efficacy of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus*.

| Hours | Concentration (mg/L) | Petroleum ether | Chloroform | Ethyl acetate | Methanol |
|---|---|---|---|---|---|
| 24 | 62.5 | 4.33 ± 2.51$^{b}$ (21.6) | 0.00 ± 0.00$^{a}$ (0.0) | 1.00 ± 1.00$^{a}$ (5.0) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 10.00 ±1.00$^{c}$ (50.0) | 0.33 ± 0.57$^{a}$ (1.6) | 3.33 ± 1.52$^{b}$ (16.5) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 250 | 13.66 ± 0.57$^{d}$ (68.3) | 1.00 ± 1.00$^{a}$ (5.0) | 7.66 ± 1.52$^{c}$ (38.3) | 0.33 ± 0.57$^{a}$ (1.6) |
| | 500 | 15.33 ± 1.52$^{d}$ (76.6) | 6.33 ± 0.57$^{b}$ (31.6) | 11.00 ± 1.00$^{d}$ (55.0) | 1.66 ± 0.57$^{b}$ (8.3) |
| | 1000 | 19.00 ± 1.00$^{e}$ (95.0) | 15.00 ±1.00$^{c}$ (75.0) | 16.00 ± 1.00$^{e}$ (80.0) | 4.33 ± 1.15$^{c}$ (21.6) |
| 48 | 62.5 | 9.00 ± 2.00$^{b}$ (45.0) | 0.33 ± 0.57$^{a}$ (1.6) | 2.33 ± 0.57$^{b}$ (11.6) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 12.33 ±1.52$^{c}$ (61.6) | 2.33 ± 1.52$^{a}$ (11.6) | 4.00 ± 1.00$^{c}$ (20.0) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 250 | 16.00 ± 0.00$^{d}$ (80.0) | 5.33 ± 1.52$^{b}$ (26.6) | 11.66 ± 1.15$^{d}$ (58.3) | 0.33 ± 0.57$^{a}$ (1.6) |
| | 500 | 20.00 ± 0.00$^{e}$ (100.0) | 11.00 ± 1.73$^{c}$ (55.0) | 13.66 ± 1.52$^{e}$ (68.3) | 3.66 ± 0.57$^{b}$ (18.3) |
| | 1000 | 20.00 ± 0.00$^{e}$ (100.0) | 17.33 ± 2.08$^{d}$ (86.6) | 18.00 ± 1.00$^{f}$ (90.0) | 5.33 ± 0.57$^{c}$ (26.6) |
| 72 | 62.5 | 11.66 ± 1.52$^{b}$ (58.3) | 0.66 ± 0.57$^{a}$ (3.3) | 3.66 ± 0.57$^{b}$ (18.3) | 0.00 ± 0.00$^{a}$ (0.0) |
| | 125 | 15.00 ± 1.00$^{c}$ (75.0) | 4.00 ± 1.00$^{b}$ (20.0) | 11.33 ± 2.30$^{c}$ (56.6) | 0.33 ± 0.57$^{a}$ (1.6) |
| | 250 | 18.00 ± 1.00$^{d}$ (90.0) | 9.33 ± 1.52$^{c}$ (46.6) | 15.00 ± 1.00$^{d}$ (75.0) | 1.33 ± 1.52$^{a}$ (6.5) |
| | 500 | 20.00 ±0.00$^{e}$ (100.0) | 14.33 ± 2.08$^{d}$ (71.6) | 19.00 ± 1.00$^{e}$ (95.0) | 4.33 ± 1.15$^{b}$ (21.6) |
| | 1000 | 20.00 ± 0.00$^{e}$ (100.0) | 19.33 ± 1.15$^{e}$ (96.6) | 19.33 ± 1.15$^{e}$ (96.6) | 7.33 ± 1.15$^{c}$ (36.6) |

Values are mean of three replicates of three trials ± standard deviation. Values in parenthesis denote per cent larval mortality. Different superscript alphabets indicate statistical significant difference in larval mortality between concentrations at $P<0.05$ level by one way ANOVA followed by DMRT.

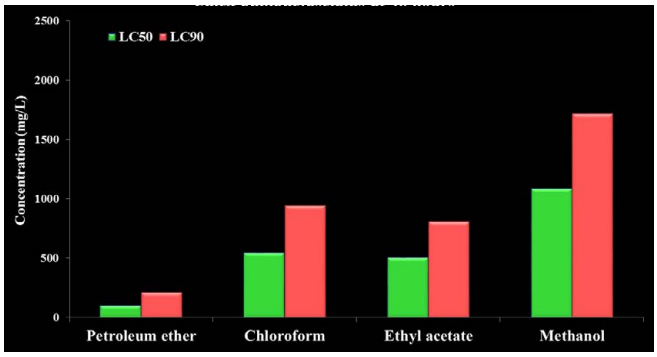


**Figure 8:** Probit analysis of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 48 hours.

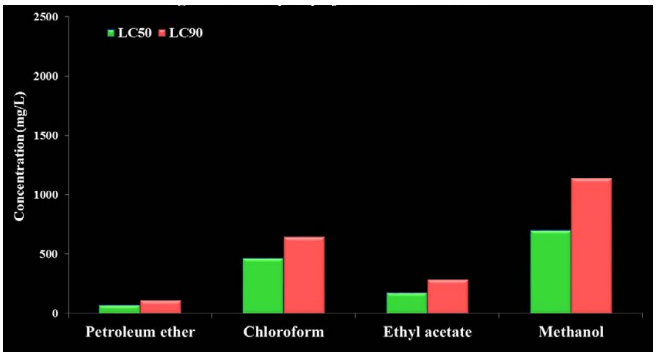


**Figure 10:** Probit analysis of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

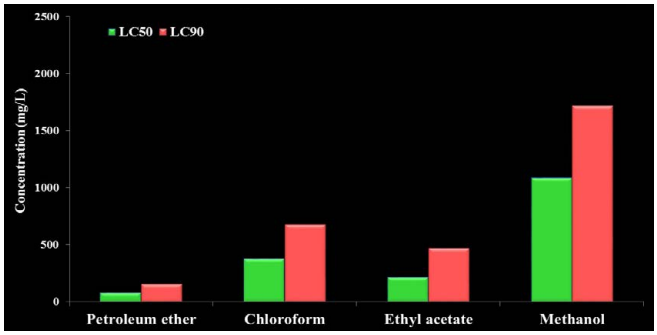


**Figure 9:** Probit analysis of *Melia dubia* crude leaf extracts against *Culex quinquefasciatus* at 72 hours.

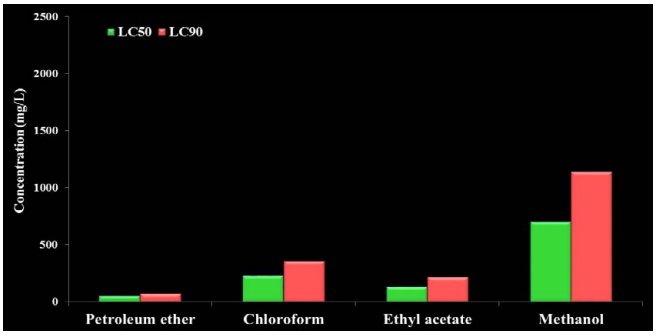


**Figure 11:** Probit analysis of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

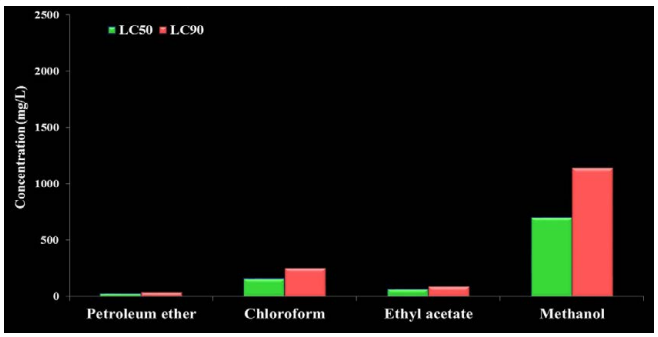


**Figure 12:** Probit analysis of *Swietenia mahagoni* crude leaf extracts against *Culex quinquefasciatus* at 24 hours.

against *Culex quinquefasciatus* in the recent years [21,28,30,31,118-123] and results of the crude petroleum ether extract of *Swietenia mahagoni* and *Melia dubia* of the present study opens a new horizon of researches pertaining to biocontrol efficacy of plants. The purification and determination of the structure of active ingredients of the plant is necessary for its wide use in mosquito control programme. Researchers continue to explore a growing number of botanical compounds and phytochemicals in the hope that they may eventually replace synthetic insecticides for mosquito control as a more safe and sustainable alternative [33]. Proponents of botanical compounds often claim that they offer promises in future mosquito control programs on account of their minimal hazardous effect on the environment and wide ranging availability. However, it must be noted that many plants produce compounds that are highly toxic to mammals and some are irritating to the skin, so the word 'natural' does not always equate to 'safe' [124]. Nevertheless, phytochemcials have the potential to revolutionize the field of vector control in the same way that they have revolutionized medicine, since they possess an unknown variety of bioactive components that may be effective as general toxicants against various juvenile and adult stages of mosquitoes and other insect vectors of human diseases besides having a future in the insecticide industry.

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