A review on plant phytochemicals potential for mosquito control

A Shajahan, MI ZahirHussian, S Ramesh Kumar and K Ajintha

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Abstract
Most serious diseases like malaria, yellow fever, dengue fever, chikungunya fever, filariasis, encephalitis, West Nile Virus infection, etc. are spread by mosquitoes. The use of alternate mosquito control methods was emphasized under the Integrated Mosquito Management (IMM). The continuous utility of artificial pesticides reasons improvement of resistance in vector species, Organic magnification of poisonous substances through the food chain and adverse effects on environmental and non-target organisms which includes human fitness Since ancient times, active poisonous compounds from plant extracts have been applied as a substitute method of controlling mosquitoes. These exhibit broad-spectrum target-specific actions against several kinds of vector mosquitoes while being nontoxic, easily accessible at reasonable rates, and biodegradable. This article reviews the current state of knowledge regarding phytochemical actions and mosquitocidal activity, their mode of action on the target population, variation in their larvicidal activity according to mosquito species, instar specificity, polarity of solvents used during extraction, nature of active ingredient, and promising developments made in the biological control of mosquitoes by plant derived secondary metabolites.

Keywords: Mosquito, phytochemical, larvicidal, integrated mosquito management (IMM)

1. Introduction
Mosquitoes (Diptera: Culicidae) are the primary vectors of several deadly diseases, including malaria, filariasis, dengue fever, Japanese encephalitis, and others, in practically all tropical and subtropical nations. More than 100 species of mosquitoes have been documented to be able to infect humans with diseases, out of the approximately 3000 species of mosquitoes that have been identified globally [1]. Over 700,000,000 individuals worldwide contract mosquito-borne diseases each year, which are widespread in more than 100 nations [2]. With almost 40,000,000 people in India impacted by diseases spread by mosquitoes each year, the statistic is disturbing [3]. Mosquitoes have been dubbed “public enemy number one” by WHO. An estimated one to two million people die each year from malaria worldwide. At least 120 million people in 73 countries, including those in Africa, India, Southeast Asia, and the Pacific Islands, are said to be affected by lymphatic filariasis. According to statistics, India accounts for roughly 40% of the world’s cases of filariasis, with an estimated 720 crores in yearly economic losses [3]. The incidence of Japanese encephalitis is estimated to be between 30,000 and 50,000 per year, with a fatality rate of 10,000 [4]. In developing nations like India, mosquito-borne diseases not only have a high rate of morbidity and mortality but also significantly disrupt social order and cause significant economic loss. Mosquito management is crucial to preventing the spread of diseases transmitted by mosquitoes, as well as to enhance environmental quality and human health. Application of synthetic insecticides such as organo chlorine and organophosphate chemicals is the main instrument in mosquito control operations. However, because of operational, ecological, economic, technical, and human concerns, this has not been particularly successful. Many of the former synthetic insecticides have recently seen less use in programs to control mosquitoes. It is because there aren’t enough new insecticides, synthetic insecticides are expensive, environmental sustainability is a concern, human health and other populations are negatively impacted, they aren’t biodegradable, the rate of biological magnification through ecosystems is higher, and insecticide resistance is rising globally [5, 6].
Therefore, a number of laws and regulations have been developed by the Environmental Protection Act of 1969 to restrict the use of chemical control agents in nature [7]. It has led researchers to search for alternative methods, such as offering or encouraging the adoption of transparent, efficient, and public-education-focused mosquito management strategies that emphasize source reduction, monitoring, and surveillance, as well as environmentally friendly, least-toxic larval control. These issues have led to a desire to search for environmentally benign, economically viable, biodegradable, and mosquito species-specific pesticides. In light of this, the deployment of environmentally benign alternatives, such as biological vector management, has emerged as the main objective of the control program for chemical pesticides. Exploring the floral biodiversity and entering the field of employing safer insecticides of botanical origin as a direct and sustainable means of mosquito control is one of the most effective alternative approaches under the biological control strategy. Additionally, plant-derived pesticides contain botanical mixtures of chemical compounds that operate cooperatively on both behavioral and physiological processes, in contrast to conventional insecticides, which are based on a single active ingredient. Thus, the chance of pests building a resistance to such compounds is extremely low. For vector control management to remain effective, finding bioinsecticides that are effective, appropriate, and adaptable to ecological settings is essential [8].

2. Phytochemicals or bioactive compound
Botanical pesticides that are naturally occurring and derived from floral sources are called phytochemicals. Since the 1920s, phytochemicals have been used to control mosquitoes [10], but the development of synthetic insecticides like DDT in 1939 put an end to the use of phytochemicals in mosquito control programs. The decision to focus again on phytochemicals that are readily biodegradable and have no negative effects on non-target creatures was applauded after experiencing numerous issues as a result of the excessive and careless application of synthetic pesticides in nature. Since then, efforts have been made to identify the structure of new bioactive chemicals from the plant kingdom as well as to start their commercial production. Currently, phytochemicals account for up to 1% of the global pesticide market [9].

Botanicals are basically secondary metabolites that help plants defend themselves against herbivore predators' constant selection pressure and other environmental conditions. Alkaloids, steroids, terpenoids, essential oils, and phenolics are only a few of the classes of phytochemicals from various plants that have been reported for their insecticidal properties in the past [9].

Plant extracts' insecticidal properties differ depending on the extraction method employed and the polarity of the solvents used, in addition to factors like plant and mosquito species, geographical variation, and the parts used. The extraction of mosquito poisons involved the utilization of a wide range of plants, including herbs, shrubs, and big trees. Small herbs' entire bodies as well as the numerous fruits, leaves, stems, barks, roots, and other parts of larger plants and trees were used to extract phytochemicals. For the purpose of controlling mosquitoes, the most harmful chemicals were always sought out, located, and extracted. Numerous compounds that are produced by plants, many of which have anti-inflammatory and pesticide effects. There are around 2000 plant species that are known to produce valuable chemical components and metabolites. It is known that more than 2000 plant species generate chemical components and metabolites useful in pest management programs. The plant families Solanaceae, Asteraceae, Cladophoraceae, Labiatae, Miliaeceae, Oocystaceae, and Rutaceae all exhibit diverse mosquito larval, adulticidal, or repellent properties [9].

3. Integrated Mosquito Management (IMM)
To keep mosquito vector populations low, integrated mosquito management (IMM) employs a variety of techniques and tactics. It is a method for managing mosquito populations through decision-making. IMM aims to protect people from diseases spread by mosquitoes, preserve a healthy environment through responsible pesticide use and disposal, and enhance overall quality of life through practical and efficient mosquito control measures [8]. One of the tactics used by the WHO to combat tropical illnesses is the destruction of vectors or intermediary hosts. Because mosquitoes are generally immobile during the immature stage and remain more concentrated than they do in the adult form, controlling them at the larval stage is more effective and target specific than any other IMM avenues [12].

3.1 The importance of plant extracts in IMM
Insects and plants have coevolved, giving plants a variety of chemical defenses that can be utilized to repel insects [13]. More than 2000 plant species have been identified as producing secondary metabolites useful in biological pest management efforts to far, and 344 of these have been linked to considerable anti-mosquito action [14]. According to reports, representatives of the plant families Solanaceae, Asteraceae, Cladophoraceae, Labiatae, Miliaeceae, Oocystaceae, and Rutaceae have larvicial, adulticidal, or repellent effects on certain mosquito species [9]. A defense mechanism against insect and pest attacks is provided by the secondary metabolites that are found in plants. The biological activity of plant extracts against the target pest is attributed to the presence of compounds like phenolics, terpenoids, and alkaloids that act as anti-feedants, mouthing hormones, oviposition deterrents, repellents, juvenile hormone mimics, growth inhibitors, anti-mounting hormones, as well as attractants. Due to their ability to regulate growth, citrus limonoids from the Rutaceae have drawn more concern [15].

Citrus compounds such as limonin, nomilin, obacunone, epilimonom, and limonin diosphenol can easily be extracted from citrus seeds, which are widely available as waste products of the citrus industry. It has been discovered that citrus limonoids can both cause toxicity and serve as a feeding deterrent. The furan ring and epoxide groups in the citrus limonoid structure have been found to be essential for the limonoid's antifeedant effect in studies of the structure-activity relationship of limonin. Limonoids cause nutritional disruption, which results in antifeedant effects and eventually affects how insects lay their eggs [16].

4. Larvicidal potential varies depending on mosquito species, plant components, and solvent based polarity
The effectiveness of phytochemicals against mosquito larvae might vary greatly depending on the plant species, plant parts employed, age of plant parts (young, mature, or senescent), extraction solvent, as well as the species of vectors that are present. Sukumar et al. [17] have discussed the existence of
variations in the extent to which phytochemical compounds are effective on target mosquito species relative to 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, photosensitivy of some of the compounds in the extract, and effect on growth and reproduction.

### Table 1: Efficacy of botanical extracts in controlling/reducing the population of vector mosquitoes

| Sl. No | Solvents                        | Plant species                  | Plant parts used       | Target mosquito species                         | References                  |
|--------|---------------------------------|-------------------------------|------------------------|-------------------------------------------------|-----------------------------|
| 1      | Petroleum ether solvent extract | Artemisia annua               | Leaf                   | Anopheles stephensi                             | Sharma et al. (2006)        |
| 2      | Petroleum ether solvent extract | Acacia nilotica              | Leaf                   | Anopheles stephensi                             | Saktivadivel & Daniel (2008) |
| 3      | Petroleum ether solvent extract | Argemone mexicana            | Leaf, seed             | Anopheles stephensi                             | Saktivadivel & Daniel (2008) |
| 4      | Petroleum ether solvent extract | Jatropha curcas              | Leaf                   | Anopheles stephensi                             | Saktivadivel & Daniel (2008) |
| 5      | Petroleum ether solvent extract | Withania sommifera           | Leaf                   | Anopheles stephensi                             | Saktivadivel & Daniel (2008) |
| 6      | Petroleum ether solvent extract | Citrullus colocynthis        | Leaf                   | Anopheles stephensi                             | Saktivadivel & Daniel (2008) |
| 7      | Petroleum ether solvent extract | Aloe barbadensis             | Leaf                   | Anopheles stephensi                             | Maurya et al. (2007)        |
| 8      | Petroleum ether solvent extract | Cannabis sativa              | Leaf                   | Anopheles stephensi                             | Maurya et al. (2007)        |
| 9      | Petroleum ether solvent extract | Eucalyptus globules          | Seed, leaf             | Culex pipiens                                   | Sheeren et al. (2006)       |
| 10     | Petroleum ether solvent extract | Solanum xanthocarpum         | Root                   | Cx. pipiens pullens                             | Mohan et al. (2006)         |
| 11     | Petroleum ether solvent extract | Thymus capitatus             | Leaf                   | Cx. pipiens                                     | Mansour et al. (2000)       |
| 12     | Petroleum ether solvent extract | Citrus aurantium             | Fruit peel             | Cx. quinquefasciatus                            | Kassir (1989)               |
| 13     | Petroleum ether solvent extract | Myrtus communis              | Flower and Leaf        | Cx. pipiens pullens                             | Traboulsee et al. (2002)    |
| 14     | Petroleum ether solvent extract | Oreganum syriacum            | Leaf                   | Cx. pipiens pullens                             | Traboulsee et al. (2002)    |
| 15     | Petroleum ether solvent extract | Mentha pulegium              | Leaf                   | Cx. pipiens pullens                             | Traboulsee et al. (2002)    |
| 16     | Petroleum ether solvent extract | Pistacia lentiscus           | Leaf                   | Cx. pipiens pullens                             | Traboulsee et al. (2002)    |
| 17     | Petroleum ether solvent extract | Lavandula stoechas           | Leaf                   | Cx. pipiens pullens                             | Traboulsee et al. (2002)    |
| 18     | Petroleum ether solvent extract | Jatropha curcas              | Leaf                   | Cx. quinquefasciatus                            | Rahuman et al. (2007)       |
| 19     | Petroleum ether solvent extract | Pedilanthus tythymoides      | Leaf                   | Cx. quinquefasciatus                            | Rahuman et al. (2007)       |
| 20     | Petroleum ether solvent extract | Phyllanthus amarus           | Leaf                   | Cx. quinquefasciatus                            | Rahuman et al. (2007)       |
| 21     | Petroleum ether solvent extract | Argemone mexicana            | Leaf                   | Cx. quinquefasciatus                            | Karmegam et al. (1996)      |
| 22     | Petroleum ether solvent extract | Jatropha curcas              | Leaf                   | Cx. quinquefasciatus                            | Karmegam et al. (1996)      |
| 23     | Petroleum ether solvent extract | Pergularia extensa           | Leaf                   | Cx. quinquefasciatus                            | Karmegam et al. (1996)      |
| 24     | Petroleum ether solvent extract | Withania sommifera           | Leaf                   | Cx. quinquefasciatus                            | Karmegam et al. (1996)      |
| 25     | Petroleum ether solvent extract | Piper nigrum                 | Seed                   | Cx. pipiens                                     | Shalaan et al. (2005)       |
| 26     | Petroleum ether solvent extract | Euphorbia hirta              | Stem bark              | Cx. quinquefasciatus                            | Rahuman et al. (2007)       |
| 27     | Petroleum ether solvent extract | E. tirucalli                 | Stem bark              | Cx. quinquefasciatus                            | Rahuman et al. (2007)       |
| 28     | Petroleum ether solvent extract | Ocimum basilicum             | Leaf                   | An. stephensi and Cx. quinquefasciatus          | Maurya et al. (2009)        |
| 29     | Hexane solvent extract          | Momordica charantia          | Fruit                  | An. stephensi                                   | Singh et al. (2006)         |
| 30     | Hexane solvent extract          | Momordica charantia          | Fruit                  | Cx. quinquefasciatus                            | Singh et al. (2006)         |
| 31     | Hexane solvent extract          | Morinda charantia            | Fruit                  | Ae. aegypti                                     | Singh et al. (2006)         |
| 32     | Hexane solvent extract          | Kaempferia galanga           | Rhizome                | Cx. quinquefasciatus                            | Choochote et al. (1999)     |
| 33     | Hexane solvent extract          | Khaya senegalensis           | Leaf                   | Cx. annulirostris                               | Shaalan et al. (2005)       |
| 34     | Hexane solvent extract          | Daucus carota                | Leaves                 | Cx. annulirostris                               | Shaalan et al. (2005)       |
| 35     | Hexane solvent extract          | Cercium aromaticum           | Rhizome                | Ae. aegypti                                     | Choochote et al. (2005)     |
| 36     | Hexane solvent extract          | Cistus axifolissplicata      | Stem wood              | Ae. aegypti                                     | Rodrigues et al. (2005)     |
| 37     | Hexane solvent extract          | Eucalyptus citriodora        | Leaf                   | An. stephensi, Cx. Quinque-fasciatus, Ae. aegypti| Singh et al. (2007)         |
| 38     | Hexane solvent extract          | Solanum nigrum              | Dried fruit            | An. Callicofies, An. Stephanie, Cx. Quinque-fasciatus, Ae. aegypti | Raghavendra et al. (2009) |
| 39     | Acetone solvent extract         | Tridax procumbens            | Leaf                   | An. subpticus                                   | Kamaraj et al. (2011)       |
| 40     | Acetone solvent extract         | Ageratum conyzoides          | Leaf                   | Cx. quinquefasciatus                            | Saxena et al. (1992)        |
| 41     | Acetone solvent extract         | Cleome icosandra            | Leaf                   | Cx. quinquefasciatus                            | Saxena et al. (1992)        |
| 42     | Acetone solvent extract         | Tridax procumbens            | Leaf                   | Cx. quinquefasciatus                            | Saxena et al. (1992)        |
| 43     | Acetone solvent extract         | Ageratina adenophora         | Twigs                  | Ae. aegypti and Cx. quinquefasciatus            | Raj Mohan & Ramaswamy (2007) |
| 44     | Acetone solvent extract         | Feronia limonia              | Leaf                   | Cx. Quinquefasciatus, An. stephensi, Ae. aegypti| Rahuman et al. (2000)       |
| 45     | Acetone solvent extract         | Millingtonia hortensis      | Leaf                   | An. stephensi, Ae. aegypti and Cx. quinquefasciatus| Kausik & Sanyi (2008)      |
| 46     | Acetone solvent extract         | O. sanctum                   | Leaf                   | Ae. aegypti, Cx. quinquefasciatus               | Anees (2008)                |
| 47     | Carbon tetra chloride solvent  extract | Aloe barbadensis | Leaf                   | An. stephensi                                   | Maurya et al. (2007)        |
| 48     | Carbon tetra chloride solvent  extract | S. santhocarpum | Root                   | Cx. pipiens pullens                             | Mohan et al. (2006)         |
| 49     | Carbon tetra chloride solvent  extract | E. globulus                | Seed and leaf          | Cx. pipiens                                     | Sheeren (2006)              |
| 50     | Chloroform extract             | Plumbago zeylanica, P. diweii and P. stenosphylla | Root | An. gambiue | Maniata et al. (2009)    |
| 51     | Chloroform extract             | Euphorbia tirucalli         | Latex and stem bark    | Cx. pipiens pullens                             | Yadav et al. (2002)         |
| 52     | Chloroform extract             | Nucathanes arborritis       | Flower                 | Cx. quinquefasciatus                            | Khutun et al. (2001)        |
| 53     | Chloroform extract             | Citrus sinensis             | Fruit peel             | An. subpticus                                   | Bagavan et al. (2009)       |
| 54     | Chloroform extract             | Aloe aragonensis            | Leaf                   | An. aragonensis                                 | Matsuki et al. (2002)       |
| 55     | Chloroform extract             | Millettia dura              | Seed                   | Ae. aegypti                                     | Yenesew et al. (2003)       |
| 56     | Chloroform extract             | Cassia obovifolia           | Seed                   | Ae. Aegypti, Ae. igotii, and Cx.                | Yang et al. (2003)          |
| No. | Extraction Method          | Plant Name                        | Part Used                      | Species                          | Source(s)                               |
|-----|---------------------------|----------------------------------|--------------------------------|---------------------------------|-----------------------------------------|
| 57  | Methanol extract          | Atlanticia monophylla           | Leaf                           | An. stephensi                   | Sivagnaname & Kalyanasundaram (2004)    |
| 58  | Methanol extract          | Diospyros Malabaricum           | Leaf                           | An. stephensi                   | Senthil Nathan et al. (2006)            |
| 59  | Methanol extract          | Melia azedarach                  | Leaf and seeds                 | An. stephensi                   | Senthil Nathan et al. (2006)            |
| 60  | Methanol extract          | Morinda oleifera                | Bark                           | Cx. gelidus                     | Kamaraj & Rahuman (2010)               |
| 61  | Methanol extract          | Ocimum gratissimum              | Leaf                           | Cx. gelidus                     | Kamaraj & Rahuman (2010)               |
| 62  | Methanol extract          | Solenostemma argel              | Aerial parts                    | Cx. pipiens                     | Al-Doghaire et al. (2004)              |
| 63  | Methanol extract          | S. xanthocarpum                 | Root                           | Cx. pipiens                     | Mohan et al. (2006)                    |
| 64  | Methanol extract          | Chrysanthemum indicum           | Leaf                           | Cx. tritaeniorhynchus           | Kamaraj et al. (2010)                  |
| 65  | Methanol extract          | Acalypha alnifolia              | Leaf                           | Cx. pipiens                     | El Hag et al. (1999)                   |
| 66  | Methanol extract          | Rhazya stricta                  | Leaf                           | Cx. pipiens                     | El Hag et al. (1999)                   |
| 67  | Methanol extract          | Momordica charantia             | Leaf                           | Cx. quinquefasciatus            | Prabakar & Jebanesan (2004)            |
| 68  | Methanol extract          | Trichosanthes anguina           | Leaf                           | Cx. quinquefasciatus            | Prabakar & Jebanesan (2004)            |
| 69  | Methanol extract          | Luffa acutangula                | Leaf                           | Cx. quinquefasciatus            | Prabakar & Jebanesan (2004)            |
| 70  | Methanol extract          | Benincasa ciferita              | Leaf                           | Cx. quinquefasciatus            | Prabakar & Jebanesan (2004)            |
| 71  | Methanol extract          | Citrullus vulgaris              | Leaf                           | Cx. quinquefasciatus            | Prabakar & Jebanesan (2004)            |
| 72  | Methanol extract          | Vitex negundo                   | Leaf                           | Cx. quinquefasciatus            | Krishnan et al. (2007)                 |
| 73  | Methanol extract          | V. trifolia                    | Leaf                           | Cx. quinquefasciatus            | Krishnan et al. (2007)                 |
| 74  | Methanol extract          | V. peduncularis                 | Leaf                           | Cx. quinquefasciatus            | Krishnan et al. (2007)                 |
| 75  | Methanol extract          | V. alitissima                   | Leaf                           | Cx. quinquefasciatus            | Krishnan et al. (2007)                 |
| 76  | Methanol extract          | Centella asiatica               | Leaf                           | Cx. quinquefasciatus            | Rajkumar & Jebanesan (2005)            |
| 77  | Methanol extract          | Euphorbia tirucalli            | Latex and stem bark            | Cx. pipiens                     | Yadav et al. (2002)                    |
| 78  | Methanol extract          | Eucalyptus globulus            | Seed and leaf                  | Cx. Pipiens                     | Sheeren (2006)                         |
| 79  | Methanol extract          | Atlanticia monophylla           | Leaf                           | Cx. Quinquefasciatus            | Sivagnaname & Kalyanasundaram (2004)   |
| 80  | Methanol extract          | Pavonia ceylanica              | Leaf                           | Cx. Quinquefasciatus            | Valitha et al. (2002)                  |
| 81  | Methanol extract          | Acacia ferruginea               | Leaf                           | Cx. Quinquefasciatus            | Valitha et al. (2002)                  |
| 82  | Methanol extract          | Coccinia indica, Cucumis sativus, Momordica charantia | Leaf | Cx. Quinquefasciatus and Ae. aegypti | Rahuman & Venkatesan (2008) |
| 83  | Methanol extract          | Cassia tora                     | Seed                           | Ae. aegypti and Cx. pipiens pallen | Jang et al. (2002) |
| 84  | Methanol extract          | Atlanticia monophylla           | Leaf                           | Ae. Aegypti                     | Sivagnaname & Kalyanasundaram (2004)   |
| 85  | Methanol extract          | Coccinia indica, Cucumis sativus, Momordica charantia | Leaf | Ae. Albopictus | Rahuman & Venkatesan (2008) |
| 86  | Methanol extract          | Aristolochia saccata            | Root                           | Ae. Albopictus                  | Das et al. (2007)                      |
| 87  | Methanol extract          | Annona squamosa                 | Leaf                           | Ae. Albopictus                  | Das et al. (2007)                      |
| 88  | Methanol extract          | Gymnopetalum cochinibinensis     | Fruit/ pericarp                | Ae. Albopictus                  | Das et al. (2007)                      |
| 89  | Methanol extract          | Caesalpinea sp.                | Bark                           | Ae. Albopictus                  | Das et al. (2007)                      |
| 90  | Methanol extract          | Piper sp.                      | Stem                            | Ae. Albopictus                  | Das et al. (2007)                      |
| 91  | Methanol extract          | Chamaeclipsis obtusa            | Leaf                           | An. Stephensi                   | Jang et al. (2005)                     |
| 92  | Methanol extract          | Acalypsa alnifolosa             | Leaf                           | An. stephensi, Ae. aegypti and Cx. quinquefasciatus | Kovenden et al. (2012) |
| 93  | Chloroform: methanol extract (1:1) | Solanum villosum             | Leaf                           | An. Stephensi                   | Chowdhury et al. (2009)                |
| 94  | Chloroform: methanol extract (1:1) | Cestrum diurnum              | Leaf                           | An. Stephensi                   | Ghosh & Chandra (2006)                 |
| 95  | Chloroform: methanol extract (1:1) | Cestrum diurnum              | Leaf                           | Cx. Quinquefasciatus            | Ghosh et al. (2008)                    |
| 96  | Chloroform: methanol extract (1:1) | Solanum villosum             | Berry                          | Ae. Aegypti                     | Chowdhury et al. (2008)                |
| 97  | Ethanol Extract           | Cassia obtusifolia             | Leaf                           | An. Stephensi                   | Rajkumar & Jebanesan (2009)            |
| 98  | Ethanol Extract           | Azadirachta indica             | Leaf                           | Cx. Fatigans                    | Azmi et al. (1998)                     |
| 99  | Ethanol Extract           | Piper retrofructum             | Unripe and ripe fruit          | Cx. Quinquefasciatus            | Chansang et al. (2005)                 |
| 100 | Ethanol Extract           | Citrus reticulata              | Seed                           | Cx. quinquefasciatus and Ae. aegypti | Sunrophiion et al. (2006)              |
| 101 | Ethanol Extract           | Azadirachta indica             | Leaf                           | Ae. Aegypti                     | Mgbemena (2010)                       |
| 102 | Ethanol Extract           | Azadirachta indica, Ocimum gratissimum and Citrus citratus | Leaf | Ae. Aegypti | Mgbemena (2010) |
| 103 | Ethanol Extract           | Apium graveolens               | Seed                           | Ae. Aegypti                     | Choochale et al. (2004)                |
| 104 | Ethanol Extract           | Rhizophora mucronata           | Bark, pith, stem wood          | Ae. Aegypti                     | Kabara & Gichia (2001)                 |
| 105 | Ethanol Extract           | Piper longum                   | Fruit exocarp                  | Ae. Aegypti                     | Chaithong et al. (2006)                |
| 106 | Ethanol Extract           | P. ribesoides                  | Fruit exocarp                  | Ae. Aegypti                     | Chaithong et al. (2006)                |
| 107 | Ethanol Extract           | P. sarmentosum                 | Fruit exocarp                  | Ae. Aegypti                     | Chaithong et al. (2006)                |
| 108 | Ethanol Extract           | Annona crassiflora             | Root wood                      | Ae. Aegypti                     | Omna et al. (2007)                     |
| 109 | Ethanol Extract           | Annona crassiflora             | Root bark                      | Ae. Aegypti                     | Omna et al. (2007)                     |
| 110 | Ethanol Extract           | Annona crassiflora             | Stem                           | Ae. Aegypti                     | Omna et al. (2007)                     |
| 111 | Ethanol Extract           | A. glabra                      | Seed                           | Ae. Aegypti                     | Omna et al. (2007)                     |
| 112 | Ethanol Extract           | A. muricata                    | Root                           | Ae. Aegypti                     | Omna et al. (2007)                     |
| 113 | Ethanol Extract           | A. squamosa                    | Root                           | Ae. Aegypti                     | Omna et al. (2007)                     |
| 114 | Ethanol Extract           | A. squamosa                    | Leaf                           | Ae. Aegypti                     | Omna et al. (2007)                     |
5. The nature of the active components that cause larval toxicity

The world of plants contains a vast, untapped reservoir of phytochemicals that could be widely utilized in mosquito control programs in place of industrial insecticides. Alkanes, alkenes, alkynes, and simple aromatics, lactones, essential oils, fatty acids, terpenes, alkaloids, steroids, is flavonoids, and nucleic acids, are examples of secondary materials derived from plants that have the potential to kill mosquito larvae. (Kishore et al. [2007] [85] reviewed the effectiveness of phytochemicals against mosquito larvae according to their chemical nature. Additionally, they reported on the isolation of numerous bioactive toxic components from a variety of plants and their toxicity toward diverse mosquito species.

6. Mode of action of phytochemicals in target insect body

Secondary metabolites that have evolved to defend plants from herbivores typically make up the poisonous active components in plant extracts. These secondary metabolites may expose the insects to poisonous compounds that have relatively non-specific effects on a variety of molecular targets as they are consumed by the insects. These targets include proteins (including structural proteins, enzymes, receptors, signaling molecules, ion channels, and receptors), nucleic acids, bio membranes, and other cellular components [86]. The principal result of this is abnormality in the nervous system (such as, in neurotransmitter synthesis, storage, release, binding, and re-uptake, receptor activation and function, enzymes involved in signal transduction pathway), which in turn affects insect physiology in many different ways and at various receptor sites. n a review of the mechanism of action of plant secondary metabolites on insect bodies, Rattan [86] noted several physiological disruptions, including the inhibition of acetyl cholinesterase (by essential oils), GABA-gated chloride channels (by thymol), disruption of sodium and potassium ion exchanges (by pyrethrin), and the inhibition of cellular respiration. This disruption also includes hormonal imbalance, mitotic poisoning (azadirachtin), disruption of the molecular events of morphogenesis, alteration in the behavior and memory of the cholinergic system (by essential oil), blockade of calcium channels (by cyanide), blockade of nerve cell membrane action (by sabadilla), blockade of octopamine receptors (by thymol), etc. The suppression of acetyl cholinesterase activity (AChE), which is a crucial enzyme involved in stopping the transmission of nerve impulses along synaptic pathways, is the most significant of these activities; It is well known that the modification in nerve cell membrane action (by sabadilla), blockage of calcium channels (by cyanide), blockade of nerve cell membrane action (by sabadilla), blockade of octopamine receptors (by thymol), etc. The suppression of acetyl cholinesterase activity (AChE), which is a crucial enzyme involved in stopping the transmission of nerve impulses along synaptic pathways, is the most significant of these activities; It is well known that the modification in

| 115. | Ethanol Extract | Denis sp. | Root | Ae. Aegypti | Omena et al. (2007) [79] |
| 116. | Ethanol Extract | Erisithrina mulungu | Stems bark | Ae. Aegypti | Omena et al. (2007) [79] |
| 117. | Ethanol Extract | Pyreodol polygalaeformis | Seed | Ae. Aegypti | Omena et al. (2007) [79] |
| 118. | Ethanol Extract | Tigonetis minuta | Aerial parts | Ae. Fluviatilis | Macedo et al. (1993) [74] |
| 119. | Ethanol Extract | Eclipta paniculata | Aerial parts | Ae. Fluviatilis | Macedo et al. (1997) [74] |
| 120. | Benzene extract | Citrusus vulgaris | Leaf | Ae. Stephensi | Mullia et al. (2008) [74] |
| 121. | Benzene extract | Acalypha indica | Leaf | Ae. Stephensi | Govindarajan et al. (2008) [74] |
| 122. | Benzene extract | C. vulgaris | Leaf | Ae. Aegypti | Mullia et al. (2008) [74] |
| 123. | Ethyl acetate extract | Dysosyllum malabaricum | Leaf | An. Stephensi | Senthil Nathan et al. (2008) [74] |
| 124. | Ethyl acetate extract | D. beddomei Aloe turkanensis | Leaf | An. Gambiae | Matasoyah et al. (2008) [74] |
| 125. | Ethyl acetate extract | Solanum nigrum | Leaf | Cs. Quinquefasciatus | Rawani et al. (2010) [79] |
| 126. | Ethyl acetate extract | Ocimum gratissimum | Leaf | Cs. gelidus and Cs. quinquefasciatus | Kamaraj & Rahman (2010) [79] |
| 127. | Ethyl acetate extract | Annona squamosa | Bark | Cs. Quinquefasciatus and An. stephensi | Kamaraj et al. (2010) [79] |
| 128. | Ethyl acetate extract | O. sanctum | Leaf | Ae. aegypti, Cs. quinquefasciatus | Anees (2008) [79] |
| 129. | Aqueous extract | Carica papaya | Seed | Cs. Quinquefasciatus | Rawani et al. (2009) [79] |
| 130. | Aqueous extract | Murraya paniculata | Fruit | Cs. Quinquefasciatus | Rawani et al. (2009) [79] |
| 131. | Aqueous extract | Cleistanthus collinus | Leaf | Cs. Quinquefasciatus | Rawani et al. (2009) [79] |
| 132. | Aqueous extract | Cleistanthus collinus | Leaf | An. Gambiae | Rawani et al. (2009) [79] |
| 133. | Aqueous extract | Hermisdesmus indicus | Root | Cs. Quinquefasciatus | Khanna & Kannabiran (2007) [79] |
| 134. | Aqueous extract | Gymnema sylvestre | Leaf | Cs. Quinquefasciatus | Khanna & Kannabiran (2007) [79] |
| 135. | Aqueous extract | Eclipta prostrata | Leaf, root | Cs. Quinquefasciatus | Khanna & Kannabiran (2007) [79] |
| 136. | Aqueous extract | Artemisia cina | Leaf | Cs. Pipiens | Aly & Bardan (1986) [82] |
| 137. | Aqueous extract | Cleome dosserifolia | Leaf | Cs. Pipens | Aly & Bardan (1986) [82] |
| 138. | Aqueous extract | Piper retrofractum | Un ripe and ripe fruit | Cs. Quinquefasciatus and Ae. aegypti | Chansang et al. (2005) [82] |
| 139. | Aqueous extract | Solanum villosum | Leaf | An. stephensi, Cs. quinquefasciatus and Ae. aegypti | Chowdhury et al. (2008) [82] |
| 140. | Aqueous extract | Solanum nigrum | Dried fruit | An. culicifacies species A, An. culicifacies species C, An. stephensi, Cs. quinquefasciatus and Ae. aegypti | Raghavendra et al. (2009) [82] |
| 141. | Steam distillation | Paullinia clavigera | Leaf | An. Benarrochi | Iannacone & Pérez (2004) [82] |
| 142. | Steam distillation | Tradescantia zebrina | Leaf | An. Benarrochi | Iannacone & Pérez (2004) [82] |

7. Conclusion

A global issue involving mosquitoes as carriers of some of the most serious disease-causing pathogens necessitates collaboration across all working groups under one overarching initiative in order to avoid repeating trials and tests and to produce some useful results soon. It is challenging to compare the repellency results from various bioassays due to the varying test circumstances, lack of homogeneity in bioassays, absence of standard materials, and fundamental assumptions associated with each bioassay system. Phytochemicals currently account for 1% of the global pesticide market. For the control of mosquito-borne diseases, it is essential to identify, isolate, and mass-produce bioactive
chemicals of plant origin. The positive outcomes of early studies on the ability of plant extracts to repel mosquitoes encourage further research into the bioactive substances found in those extracts that may be effective larvicial agents when isolated in pure form, according to the International Journal of Mosquito Research. Additionally, there is a need for time-tested drug delivery systems for active ingredients derived from plants. Finding plant-based insecticides that are effective, suitable for and adaptable to local ecological conditions, biodegradable, and have the widespread mosquitocidal characteristic will work as a new weapon in the insecticides’ armory and help reduce the use of harmful chemicals.

8. References

1. Rueda, Leopoldo M. Global diversity of mosquitoes (Insecta: Diptera: Culicidae) in freshwater. Freshwater animal diversity assessment. Springer, Dordrecht; c2007. p. 477-487.

2. Meenakshi SV, Jayaprakash K. "Mosquito larvicidal efficacy of leaf extract from mangrove plant Rhizophora mucronata (Family: Rhizophoraceae) against Anopheles and Aedes species." Journal of Pharmacognosy and Phytochemistry. 2014;3.1:78-83.

3. Bagavan A, Abdul Rahuman. Evaluation of larvicidal activity of medicinal plant extracts against three mosquito vectors. Asian Pacific journal of tropical medicine. 2011;4.1:29-34.

4. Russell, Tanya L, Brian H Kay, Greg A. Skipper. "Environmental effects of mosquito insecticides on saltmarsh invertebrate fauna." Aquatic Biology. 2009;6:77-90.

5. Bhatt, Ramesh Prasad, Sanjay Nath Khanal. "Environmental impact assessment system in Nepal–An overview of policy, legal instruments and process." Kathmandu University Journal of Science, Engineering and Technology; c2009. p. 5-2.

6. Ghosh, Anupam, Nandita Chowdhury, Goutam Chandra. "Plant extracts as potential mosquito larvicides." The Indian Journal of Medical Research. 2012;135.5:581.

7. Shaalan, Essam Abdel-Salam, et al. "A review of botanical phytochemicals with mosquitocidal potential." Environment international. 2005;31.8:1149-1166.

8. Shahi M, et al. "Larvicidal efficacy of latex and extract of Calotropis procera (Gentianales: Asclepiadaceae) against Culex quinquefasciatus and Anopheles stephensi (Diptera: Culicidae)." J Vector Borne Dis. 2010;47.3:185-188.

9. Isman, Murray B. "Neem and other botanical insecticides: barriers to commercialization". Phytoparasitica. 1997;25.4:339-344.

10. Tehri, Kanika, Naresh Singh. "The role of botanicals as green pesticides in integrated mosquito management–A review." International Journal of Mosquito Research. 2015;2.1:18-23.

11. Arivoli S, K John Ravindran, Samuel T. "Larvicidal efficacy of plant extracts against the malarial vector Anopheles stephensi Liston (Diptera: Culicidae)." World Journal of Medical Sciences. 2012;7.2:77-80.

12. Remia KM, S Logaswamy. "Larvicidal efficacy of leaf extract of two botanicals against the mosquito vector Aedes aegypti (Diptera: Culicidae);" c2010.

13. Champagne DE, et al. Light-mediated allelochemical effects of naturally occurring polycyclicenes and thiophenes from Asteraceae on herbivorous insects." Journal of chemical ecology. 1986;12.4:835-858.

14. Akram, Waseem, et al. "Potential of citrus seed extracts against dengue fever mosquito, Aedes albopictus (Skuse), (Culicidae: Diptera)." Puk J Bot. 2010;42.4:3343-3348.

15. Sukumar, Kumuda, Michael J Perich, Boobar LR. "Botanical derivatives in mosquito control: a review." Journal of the American Mosquito Control Association. 1991;7.2:210-237.

16. Sharma, Preeti, Lalit Mohan, Srivastava CN. "Phytoextract-induced developmental deformities in malaria vector". Bio resource Technology. 2006;97.14:1599-1604.

17. Sakthivadivel, Murugesan, Thilagavathy Daniel. "Evaluation of certain insecticidal plants for the control of vector mosquito’s viz. Culex quinquefasciatus, Anopheles stephensi and Aedes aegypti." Applied Entomology and Zoology. 2008;43.1:57-63.

18. Maurya, Prejwitta, et al. "Larvicidal efficacy of Aloe barbadensis and Cannabis sativa against the malaria vector Anopheles stephensi (Diptera: Culicidae)." Entomological research. 2007;37.3:153-156.

19. Ghosh, Anupam, Nandita Chowdhury, Goutam Chandra. "Plant extracts as potential mosquito larvicides." The Indian Journal of Medical Research. 2012;135.5:581.

20. Mohan, Lalit, Preeti Sharma, Srivastava CN. "Evaluation of Solanum xanthocarpum extract as a synergist for cypermethrin against larvae of the filarial vector Culex quinquefasciatus (Say)." Entomological research. 2006;36.4:220-225.

21. Kassir JT, Mohsen ZH, Mehdi NS. "Toxic effects of limonene against Culex quinquefasciatus Say larvae and its interference with oviposition." Anziger für Schädlingskunde, Pflanzenschutz, Umweltschutz. 1989;62.1:19-21.

22. Traboulsi, Abdallah F, et al., "Insecticidal properties of essential plant oils against the mosquito Culex pipiens molestus (Diptera: Culicidae)." Pest management science 2002;58.5:491-495.

23. Karmegam N, et al. Indigenous-plant extracts as larvicidal agents against Culex quinquefasciatus Say. Bio resource technology. 1997;59.2-3:137-140.

24. Rahuman, Abdul A, Venkatesan P. "Larvicidal efficacy of five curcubitaceous plant leaf extracts against mosquito species. Parasitology research. 2008;103.1:133-139.

25. Maurya P, Sharma p, Mohan L, Batabyal L, Srivastava CN. Evaluation of the toxicity of different phytoextracts of Ocinum basilicum against Anopheles stephensi and Culex quinquefasciatus. J Asia Pac Entomol. 2009;12:113-115.

26. Singh RK, Dhiman RC, Mittal PK. "Mosquito larvicidal properties of Morinda charantia Linn (family: Cucurbitaceae)." Journal of Vector Borne Diseases. 2006;43.2:88.

27. Choochote W, et al. "Larvicidal, adulticidal and repellent effects of Kaempferia galanga.” The Southeast Asian Journal of Tropical Medicine and Public Health. 1999;30.3:470-476.

28. Choochote Wej, et al. "Chemical composition and anti-mosquito potential of rhizome extract and volatile oil derived from Curcuma aromatica against Aedes aegypti
29. Rodrigues AMS, et al. Larvicidal activity of Cybistax antisyphilictica against Aedes aegypti larvae." Fitoterapia. 2005;76:7-8:755-757.

30. Singh RK, Dhiman RC, Mittal PK. Studies on mosquito larvicidal properties of Eucalyptus citriodora Hook (family-Myrtaceae). The Journal of Communicable Diseases. 2007;39:4-233-236.

31. Raghavendra K, et al. "Laboratory studies on mosquito larvicidal efficacy of aqueous & hexane extracts of dried fruit of Solanum nigrum Linn." Indian Journal of Medical Research. 2009;130:1-74.

32. Kamaraj C, et al. "Larvicidal activity of medicinal plant extracts against Anopheles subpictus & Culex tritaeniorhynchus." The Indian journal of medical research. 2011;134:1:101.

33. Saxena RC, Dixit OP, Padma Sukumaran. "Laboratory assessment of indigenous plant extracts for anti-juvenile hormone activity in Culex quinquefasciatus," The Indian Journal of Medical Research. 1992;95:204-206.

34. Mohan D Raj, Ramaswamy M. "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." African Journal of Biotechnology. 2007;6:5:631.

35. Rahuman, Abdul A., et al. "Effect of Feronia limonia on mosquito larvae." Fitoterapia. 2000;71:5.553-555.

36. Kaushik R, Saini P. "Larvicidal activity of leaf extract of Millingtonia hortensis (Family: Bignoniaceae) against Anopheles stephensi, Culex quinquefasciatus and Aedes aegypti." Journal of vector borne diseases. 2008;45:1.66.

37. Anees A Mohamed. "Larvicidal activity of Ocimum sanctum Linn. (Labiatae) against Aedes aegypti (L.) and Culex quinquefasciatus (Say)." Parasitology Research. 2008;103:6:1451-1453.

38. Khutnate NA, Haque ME, Mosaddik MA. Laboratory evaluation of Nytcanthes arbor-tristis Linn. Flower extract and its isolated compound against common filarial Vector, Culex quinquefasciatus Say (Diptera: culicidae) larvae." Pakistan J Biol Sci. 2001;4:5.585-587.

39. Bagavan A, et al. Evaluation of larvicidal and nymphydic potential of plant extracts against Anopheles subpictus Grassi, Culex tritaeniorhynchus Giles and Aphis gossypii Glover. Parasitology Research. 2009;104:5:1109-1117.

40. Matasyoh, Josphat C, et al. Aloe plant extracts as alternative larvicides for mosquito control." African Journal of Biotechnology; c2008. p. 7.7.

41. Yenesew, Abiy, et al. Effect of rotenoids from the seeds of Millettia dura on larvae of Aedes aegypti." Pest Management Science: formerly Pesticide Science. 2003;59:10:1159-1161.

42. Yang, Young-Cheol, Mi-Youn Lim, Hoi-Seon Lee. "Emodin isolated from Cassia obtusifolia (Leguminosae) seed shows larvicidal activity against three mosquito species." Journal of Agricultural and Food Chemistry. 2003;51:26:7629-7631.

43. Sivagnaname N, Kalyanasundaram M. "Laboratory evaluation of methanolic extract of Atlantia monophylla (Family: Rutaceae) against immature stages of mosquitoes and non-target organisms." Memórias do Instituto Oswaldo Cruz. 2004;99:115-118.

44. Senthil Nathan, Sengottayan, Kandaswamy Kalaiavani, Kim Sehoon. "Effects of Dysoxylum malabaricum Bedd. (Meliaceae) extract on the malarial vector Anopheles stephensi Liston (Diptera: Culicidae)." Bio resource technology. 2006;97:16:2077-2083.

45. Senthil Nathan, Sengottayan, Kandaswamy Kalaiavani, Kim Sehoon. "Effects of Dysoxylum malabaricum Bedd. (Meliaceae) extract on the malarial vector Anopheles stephensi Liston (Diptera: Culicidae)." Bio resource technology. 2006;97:16:2077-2083.

46. Kamaraj, Chinnaperumal, Abdul Abdul Rahuman. "Larvicidal and adulticidal potential of medicinal plant extracts from south India against vectors. Asian Pacific Journal of Tropical Medicine. 2010;3:12:948-953.

47. Al-Doghairi, Mohammed, et al. "Effect of Solenostemma argel on oviposition, egg hatchability and viability of Culex pипiens L. larvae." Phototherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2004;18:4:335-338.

48. Rajakumar G, Marimuthu S, Santhosh Kumar T. "Larvicidal efficacy of medicinal plant extracts against Anopheles stephensi and Culex quinquefasciatus (Diptera: Culicidae)." Tropical Biomedicine. 2010;27:2:211-219.

49. Prabhakar K, Jебanesа A. "Larvicidal efficacy of some cucurbitaceous plant extracts against Culex quinquefasciatus." Bio resource Tech. 2004;95:113-4.

50. Kannathasan, Krishnan, et al. "Differential larvicidal efficacy of four species of Vitex against Culex quinquefasciatus larvae". Parasitology research. 2007;101:6.1721-1723.

51. Rajkumar S, Jебanesа A. "Larvicidal and adult emergence inhibition effect of Centella asiatica Brahmi (Umbelliferae) against mosquito Culex quinquefasciatus Say (Diptera: Culicidae)." African Journal of Biomedical Research. 2005;8:1:31-33.

52. Vahitha R, et al. "Larvicidal efficacy of Pavonia zeylanica L. and Acacia ferruginea DC against Culex quinquefasciatus Say." Bio resource Technology. 2002;82:2:203-204.

53. Jang, Young-Su, et al. Larvicidal activity of leguminous seeds and grains against Aedes aegypti and Culex pипiens pallens." Journal of the American Mosquito Control Association. 2002;18:3:210-213.

54. Das NG, Goswami D, Rabha B. Preliminary evaluation of mosquito larvicidal efficacy of plant extracts. Journal of vector borne diseases. 2007;44:2:145.

55. Jang, YoungSu, Ju-Hyun Jeon, Hoi-Seon Lee. "Mosquito larvicidal activity of active constituent derived from Chamaceyparis obtusa leaves against 3 mosquito species." Journal of the American Mosquito Control Association. 2005;21:4:400-403.

56. Kovendan, Kalinuthu, Kadarkarai Murugan, Savarai Vincent. "Evaluation of larvicidal activity of Alypida alnifolia Klein ex Willd. (Euphorbiaceae) leaf extract
against the malarial vector, Anopheles stephensi, dengue vector, Aedes aegypti and Bancroftian filariasis vector, Culex quinquefasciatus (Diptera: Culicidae). Parasitology Research. 2012;110:2:571-581.

59. Chowdhury, Nandita, et al. "Larvicidal activity of Solanum villosum Mill (Solanaceae: Solanales) leaves to Anopheles subpictus Grassi (Diptera: Culicidae) with effect on non-target Chironomus circumdatus Kieffer (Diptera: Chironomidae). Journal of Pest Science. 2009;82:1:13-18.

60. Ghosh A, Chandra G. Biocontrol efficacy of Cestrum diurnum (L.) (Solanaceae: Solanaceae) against the larval forms of Anopheles stephensi. Nat Prod Res. 2006;20:3:371-9.

61. Ghosh, Anupam, Nandita Chowdhury, Goutam Chandra. "Laboratory evaluation of a phytosteroid compound of mature leaves of Day Jasmine (Solanaceae: Solanaceae) against larvae of Culex quinquefasciatus (Diptera: Culicidae) and non-target organisms." Parasitology Research. 2008;103:2:271-277.

62. Reka M, et al. "Comparative study of larvicidal activity of leaf and root extracts of Erythrina indica lam against Aedes aegypti and Culex quinquefasciatus." 2009.

63. Chowdhury, Nandita, Anupam Ghosh, Goutam Chandra. "Mosquito larvicidal activities of Solanum villosum berry extract against the dengue vector Stegomyia aegypti." BMC Complementary and Alternative Medicine. 2008;8:1:1-8.

64. Rajkumar S, Jehanesan A. "Larvicidal and oviposition activity of Cassia obtusifolia Linn (Family: Leguminosae) leaf extract against malarial vector, Anopheles stephensi Liston (Diptera: Culicidae)." Parasitology Research. 2009;104:2:337-340.

65. Azmi MA, et al. Anbreen 62B. Toxicity of neem leaves extract (NLX) compared with malathion (57 EC) against late 3rd instar larvae of Culex fatsigans (Wild Strain) by WHO method." Turk J Zool. 1998;22:213-8.

66. Chansang, Uruyakorn, et al. "Mosquito larvicidal activity of aqueous extracts of long pepper (Piper retrofractum Vahl) from Thailand. Journal of Vector Ecology. 2005:50:2:195.

67. Sumroiphon, Suchada, et al. "Bioactivity of citrus seed for mosquito borne diseases larval control." The Southeast Asian Journal of Tropical Medicine and Public Health. 2006;37:123-127.

68. Massuod, Wafi Ali Mohamed, et al. Larvicidal potentiality of the Bandotan (Ageratum conyzoides) leaves for controlling the three important species of mosquitoes (Aedes aegypti, Culex quinquefasciatus and Anopheles maculatus)." International Journal of Chemical and Biological Sciences. 2014;1:2349-2724.

69. Choochote Wej, et al. Potential of crude seed extract of celery, Apium graveolens L., against the mosquito Aedes aegypti (L.) (Diptera: Culicidae). J Vector Ecol. 2004;29:2:340-346.

70. Kabaru JM, Gichia L. "Insecticidal activity of extracts derived from different parts of the mangrove tree Rhizophora mucronata (Rhizophoraceae) Lam. against three arthropods." African Journal of Science and Technology; c2001. p. 2,2.

71. Chaithong, Udom, et al. "Larvicidal effect of pepper plants on Aedes aegypti (L.) (Diptera: Culicidae). Journal of Vector Ecology. 2006;31:1:138-144.

72. De Omena MC, et al. Larvicidal activities against Aedes aegypti of some Brazilian medicinal plants." Bio resource Technology. 2007;98:13:2549-2556.

73. Macêdo, Maria E, et al. Screening of Asteraceae (Compositae) plant extracts for larvicidal activity against Aedes fluviatilis (Diptera: Culicidae). Memórias do Instituto Oswaldo Cruz. 1997;92:565-570.

74. Mullai K, Jehanesan A, Pushpanathan T. "Mosquitoicidal and repellent activity of the leaf extract of Citrullus vulgaris (cucurbitaceous) against the malarial vector, Anopheles stephensi liston (diptera culicidae)." European Review for Medical and Pharmacological Sciences. 2008;12:1:1.

75. Govindarajan M, et al. Studies on effect of Acalypha indica L. (Euphorbiaceae) leaf extracts on the malarial vector, Anopheles stephensi Liston (Diptera: Culicidae). Parasitology Research. 2008;103:3:691-695.

76. Mullai K, Jehanesan A. "Larvicidal, ovicidal and repellent activities of the leaf extract of two cucurbitaceae plants against filarial vector Culex quinquefasciatus (Say) (Diptera: Culicidae). Trop Biomed. 2007;24:1:1-6.

77. Nathan S Senthil, Hisham A, Jayakumar G. "Larvicidal and growth inhibition of the malaria vector Anopheles stephensi by triterpenes from Dysosxylum malabaricum and Dysosxylum beddomei." Fitoterapia. 2008;79:2:106-111.

78. Rawani, Anjali, Anupam Ghosh, Goutam Chandra. Mosquito larvicidal activities of Solanum nigrum L. leaf extract against Culex quinquefasciatus Say." Parasitology Research. 2010;107:5:1235-1240.

79. Rawani, Anjali, et al. "Larvicidal activities of three plants against filarial vector Culex quinquefasciatus Say (Diptera: Culicidae)." Parasitology Research. 2009;105:5:1411-1417.

80. Gopishkanna V, Kannabiran K. "Larvicidal effect of Hemidesmus indicus, Gymnema sylvestre and Eclipta prostrata against Culex quinquefasciatus mosquito larvae. Afr J Biotechnology. 2007;6:3:307-311.

81. Aly MZY, Badran RAM. "Mosquito control with extracts from plants of the Egyptian Eastern Desert." Journal of herbs, Spices & Medicinal Plants. 1996;3:4:3-8.

82. Chowdhury, Nandita, Subrata Laskar, Goutam Chandra. "Mosquito larvicidal and antimicrobial activity of protein of Solanum villosum leaves." BMC Complementary and Alternative Medicine. 2008;8:1:1-6.

83. Jena, Mrutyunjay. "Biswaajita Pradhan, ChhandaShree Behera, Rabindra Nayak" Molecular Identification of Mosquito Vectors and Their Management; c2021. p. 51.

84. Kishore, Navneet, et al. A review on natural products with mosquitoicidal potentials. Opportunity, challenge and scope of natural products in medicinal chemistry. Kerala: Research Signpost. 2011;11:335-65.

85. Rattan, Rameshwar Singh. Mechanism of action of insecticidal secondary metabolites of plant origin." Crop Protection. 2010;29:9:913-920.

86. Ghosh, Anupam, Nandita Chowdhury, Goutam Chandra. "Plant extracts as potential mosquito larvicides. The Indian Journal of Medical Research. 2012;135:5:581.