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5. Plant Oils to Combat Mosquitoes

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Abstract. Mosquitoes are important in terms of public health, causing a number of morbidity and mortality around the world every year especially in tropical and sub-tropical regions. However, the only efficient way to control these diseases is to control mosquito vector populations and prevent mosquito bites. During the past several decades, many synthetic organic insecticides have been developed and effectively used to eliminate mosquitoes. Unfortunately, the continuous and indiscriminate use of conventional chemical insecticides for the control of mosquitoes has resulted in the development of physiological resistance in vectors against insectides and long lasting effects on non-target organisms and environment. Therefore, there is a need for development of more efficient insect control materials which have no ill effects on the non-target population, and easily degradable. Natural repellents, especially repellents from herbal essential oils are safe to humans and environment. The use of herbal products is one of the best alternatives for mosquito control. In this context, a comprehensive review of various plant extracts has been pointed as a promising alternative to combat mosquitoes.

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1. Introduction

Man has suffered from the activities of mosquito since time immemorial and it is ranked as man's most important insect pest. Mosquitoes belonging to the genera *Anopheles, Culex* and *Aedes* are the vectors for the pathogens of different diseases such as malaria, filariasis, Japanese encephalitis, dengue and dengue haemorrhagic fever, epidemic polyarthritis, yellow fever and chikungunya. These diseases devastate Indian economy every year. In general, essential oils from plants have been considered as important natural resources to act as insecticides. Essential oils play an important role in controlling several mosquito species.

WHO has declared mosquito as the "Public enemy number one" because mosquitoes are responsible for the transmission of various dreadful diseases (WHO, 1996). Knowledge of breeding, resting and biting habits and longevity of vector species is thus essential for organizing anti vector measures. A major portion of the national health budget is spent on the control of mosquitoes.

Synthetic chemicals and insecticides used for the control of vectors are being seriously questioned, because of the irreversible damage to the ecosystem, multiple resistance developed by the vectors to synthetic insecticides, in addition to high operational cost. These factors have created the need for environmentally safe, biodegradable, target specific and cost effective insecticides against mosquitoes.

Biologically active plants show a great promise for their potential efficiency as larvicides. The use of botanical derivatives against mosquito larvae, as an alternative to synthetic insecticides, offers a more ecofriendly method of insect control than the use of synthetic chemicals (Sukumar et al., 1991).

The plant world comprises a rich storehouse of biochemicals that could be tapped and used as pesticides. Plants are the richest source of renewable bio-organic chemicals. The poisonous properties of plants are due to the presence of certain toxic constituents. According to Chopra et al., 1949, vegetable bases, glycosides, flavanoids, quinones, alkaloids, carotenoids, saponins, bitter principles, toxic proteins, essential oils, resins, tannins and selenium flouride compounds are some of the important classes of toxic constituents of flora.

In short, it is proved that the heavy and indiscriminate use of synthetic pesticides culminated in contamination of the total environment including soil, air, water and food commodities. The growing concern about their illeffects on mankind, have necessitated changes in our strategies to manage insect pests in an ecofriendly manner.

The available market products as mosquito repellents are mostly synthetic or semi synthetic and they have dreadful effects on human beings especially children. It is estimated that about 90 % of the children contribute to the total death rate due to malaria (Rai et al., 2007). Hence it was felt that an exclusive plant product / herbal preparation which will be non injurious to health, will be the immediate need of the society.

2. Oviposition deterrent

Essential oil derived from rhizome of ***Achyranthes aspera*** showed oviposition deterrent activity against *Ae. aegypti* and *Cx. quinquefasciatus* (Khandagle et al., 2010). Essential oil derived from the rhizome of ***Agiaia odorata*** and ***Alpinia galanga*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from ***Cinnamomum zeylanicum, Cuminum cyminum*** (Prajapati et al., 2005) and ***Curcuma longa*** (Tawatsin et al., 2006) showed oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus*.

Essential oil derived from ***Cyperus scariosus*** showed oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oil derived from the leaves of ***Eleutherococcus trifoliatus*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dims* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from the rhizome of ***Hedychium coronarium*** and ***Houttuynia cordata*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). ***Juniperus macropoda*** oil showed oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oil derived from the seeds of ***Litsea cubeba*** exhibited oviposition deterrent activity against *Ae. aegypti*, *Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from the leaves of ***Manglietia garrettii, Melaleuca cajuputi, Murraya paniculata*** and ***Myristica fragrans*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). Essential oil of ***Nigella sativa*** showed oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). ***Ocimum basilicum*** (Prajapati et al., 2005) and ***Ocimum tenuiflorum*** (Syn : *O. sanctum*) oil (Tawatsin et al., 2006) exhibited oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus*.

Essential oil from ***Pimpinella anisum*** (Prajapati et al., 2005) and ***Piper betle*** (Tawatsin et al., 2006) showed oviposition deterrent activity against the eggs of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus*. Essential oils derived from leaves, stems and inflorescences of ***Piper marginatum*** showed oviposition deterrent activity against *Ae. aegypti* (Autran et al., 2009). Essential oil derived from the fruits of ***Piper nigrum*** and ***Psidium guajava*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil of ***Rosmarinus officinalis*** (Prajapati et al., 2005) and ***Schefflera leucantha*** (Tawatsin et al., 2006) exhibited oviposition deterrent activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus*. Essential oil derived from seeds of ***Trachyspermum ammi*** showed oviposition deterrent activity against *An. stephensi* (Pandey et al., 2009). Essential oil derived from the leaves of ***Vitex trifolia*** showed oviposition deterrent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil of ***Zingiber officinale*** showed oviposition deterrent activity against *An. stephensi, Ae. Aegypti, Cx. quinquefasciatus* (Prajapati et al., 2005 and Khandagle et al., 2010), *Ae. Albopictus* and *An. dirus* (Tawatsin et al., 2006).

3. Ovicidal activity

Essential oil derived from ***Cinnamomum zeylanicum, Cuminum cyminum*** and ***Curcuma longa*** showed ovicidal activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oils derived from ***Cymbopogan citrates*** exhibited ovicidal activity against *Cx. quinquefasciatus* (Pushpanathan et al., 2006). Essential oils derived from dried leaves of ***Cymbopogon proximus*** showed ovicidal activity against *Ae. aegypti, An. arabiensis* and *An. gambiae* (Bassole et al., 2003). Essential oil derived from ***Cyperus scariosus*** showed ovicidal activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

Juniperus macropoda oil showed ovicidal activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oils derived from dried leaves of ***Lippia multiflora*** showed ovicidal activity against *Ae. aegypti, An. arabiensis* and *An. gambiae* (Bassole et al., 2003). Essential oil of ***Nigella sativa*** showed ovicidal activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

Essential oils derived from dried leaves of ***Ocimum americanum*** (Syn : *Ocimum canum*) showed ovicidal activity against *Ae. aegypti, An. arabiensis* and *An. Gambiae*. Essential oils from ***Ocimum basilicum, Pimpinella anisum, Rosmarinus officinalis*** and ***Zingiber officinale*** exhibited ovicidal

activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

4. Repellent activity

Essential oil derived from ***Acorus calamus*** revealed repellent activity against the adults of *Cx. quinquefasciatus* (Sophia & Pandian, 2009). Essential oils derived from the leaves of ***Aglaia odorata*** revealed repellent activity against mosquito vectors of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from ***Ajania tenuifolia*** showed repellent activity against the adults of *Ae. albopictus* (Yang & Ma, 2005).

Essential oil derived from ***Aloysia citriodora*** revealed repellent activity against the adults of *An. annularis* (Gillij et al., 2008). Essential oils derived from the rhizome of ***Alpinia galanga*** revealed repellent activity against mosquito vectors of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from ***Amyris balsamifera*** revealed repellent activity against the adults of *Ae.* aegypti, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b and Paluch *et al.,* 2009). Essential oil derived from ***Andropogon citrates*** showed repellent activity against the adults of *Cx. pipiens molestus* (Traboulsi et al., 2005).

Essential oil derived from dried fruits of ***Anethum graveolens*** exhibited repellent activity against the adults of *Ae. aegypti* (Choochote et al., 2007). Essential oil derived from ***Aniba rosaeodora*** and ***Anthemis nobilis*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Essential oil derived from ***Baccharis spartioides*** exhibited repellent activity against the adults of *Ae. aegypti* (Gillij et al., 2008). Essential oil derived from leaves of ***Basilicum polystachyum*** (Syn : *Moschosma polystachyum*) showed repellency effect against the adults of *Cx. quinquefasciatus* (Rajkumar & Jebanesan, 2005). Essential oil derived from ***Boswellia carteri*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Essential oil derived from ***Cedrus deodara*** confirmed repellent effect against *Cx. quinquefasciatus* and *Ae. aegypti* (Makhaik et al., 2005). Essential oil derived from leaves of ***Centella asiatica*** showed repellency effect against *An. stephensi* (Rajkumar & Jebanesan, 2007). Essential oil derived from ***Chamaemelum nobile, Cinnamomum camphora, Cinnamomum zeylanicum*** and ***Citrus limon*** revealed repellent activity against the adults of

Ae. aegypti, An. stephensi and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b and Prajapati et al., 2005).

Essential oil derived from ***Citrus sinensis*** showed repellent activity against the adults of *Ae. albopictus* (Yang & Ma, 2005). Essential oil derived from ***Conyza newii*** and ***Croton pseudopulchellus*** showed repellent activity against the adults of *An. Gambiae* (Odalo et al., 2005). Essential oil derived from shoots of ***Cuminum cyminum*** repelled the adults of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

The volatile oil extracted from ***Curcuma aromatica*** (Choochote et al., 2005) and ***Curcuma longa*** (Sophia & Pandian, 2009) exhibited repellent effect against the adults of *Ae. aegypti*, *An. dirus* and *Cx. quinquefasciatus*. Essential oil derived from ***C. citrates*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi, Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b) and *Ae. albopictus* (Yang & Ma, 2005).

Essential oil derived from ***Cymbopogan flexuous*** revealed repellent activity against the adults of *Cx. quinquefasciatus* and *Ae. aegypti* (Makhaik et al., 2005). Essential oil derived from ***Cymbopogan martinii*** repelled the adults of *An. sundaicus* (Das & Ansari, 2003). Essential oil derived from leaves of ***Cymbopogon nardus*** showed repellent activity against the adults of *Ae. aegypti* (Trongtokit et al., 2005). Citronella oil derived from ***Cymbopogon*** spp. revealed repellent activity against *Ae. aegypti* adults (Nazli et al., 2008). Essential oil derived from ***C. winterianus*** revealed repellent activity against the adults of *Cx. quinquefasciatus* and *Ae. aegypti* (Makhaik et al., 2005).

Essential oils derived from leaves of ***Eleutherococcus trifoliatus*** revealed repellent activity against *Ae.* aegypti, *Ae. albopictus*, *An. dirus* and *Cx quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from ***Endostemon tereticaulis*** showed repellent activity against the adults of *An. gambiae* (Odalo et al., 2005).

Eucalyptus oil from ***Eucalyptis*** spp. exhibited repellent activity against the adults of *Cx. quinquefasciatus* (Sophia & Pandian, 2009). Essential oil derived from dried fruits of ***Eucalyptus camaldulensis*** showed repellent activity against the adults of *Cx. pipiens* (Erler et al., 2006). ***Eucalyptus citriodora and Eucalyptus dives*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Commercial oil derived from ***E. globulus*** showed repellent activity against the adults of *Ae. albopictus* (Yang& Ma, 2005), *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oil derived from fresh leaves of ***Eucalyptus maculata*** **citrodion** exhibited repellent activity against the adults of *Mansonia* (Hadis et al., 2003). Essential oil derived from ***Eucalyptus radiata*** revealed repellent activity

against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oil of ***Eupatorium capillifolium*** revealed repellent activity against the adults of *Ae. aegypti* (Tabanca et al., 2010).

Essential oil derived from ***Ferula galbaniflua*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oils derived from ***Ferula hermonis*** and ***Foeniculum vulgare*** showed repellent activity against the adults of *Cx. pipiens molestus* (Traboulsi et al., 2005). Essential oil derived from ***Fokienia hodginsii*** showed repellent activity against the adults of *Ae. aegypti* (Paluch et al., 2009).

Essential oil derived from ***Glycine max*** and ***Glycine soja*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Essential oils derived from rhizome of ***Hedychium coronarium*** revealed repellent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from ***Helichrysum italicum*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oils derived from flowers of ***Houttuynia cordata*** revealed repellent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from leaves of ***Ipomoea cairica*** showed repellency effect against *An. stephensi* (Rajkumar & Jebanesan, 2007). Essential oils derived from ***Jasminum grandiflorum, Juniperus communis, Juniperus macropoda*** and ***Juniperus virginiana*** (Amer & Mehlhorn, 2006b and Prajapati et al., 2005) revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus*. Essential oil derived from dried fruits of ***Kaempferia galanga*** showed repellent activity against the adults of *Ae. aegypti* (Choochote et al., 2007).

Essential oil derived from ***Laurus nobilis*** showed repellent activity against the adults of *Cx. pipiens molestus* (Traboulsi et al., 2005 and Erler et al., 2006). Essential oil derived from ***Lavandula angustifolia*** and ***Lippia citriodora*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oils derived from ***Lippia javanica*** and ***Lippia ukambensis*** showed repellent activity against the adults of *An. Gambiae.* Essential oil derived from the seeds of ***Litsea cubeba*** revealed repellent activity against the adults of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oils derived from the leaves of ***Manglietia garretti*** and ***Meialeuca cajuputi*** revealed repellent activity against *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from ***Melaleuca leucadendron*** and ***Melaleuca quinquenervia*** revealed repellent activity against the adults of *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oil derived from dried foliage of ***Mentha piperita*** showed repellent activity against the adults of *Cx. pipiens* (Erler *et al.*, 2006), *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b), *Ae. albopictus* (Yang & Ma, 2005). Commercial oil derived from ***Mentha spicata*** showed repellent activity against the adults of *Ae. albopictus* (Yang & Ma, 2005).

Essential oil derived from ***Mkilua fragrans*** revealed repellent activity against the adults of *An. gambiae* (Odalo et al., 2005). Essential oil derived from leaves of ***Momordica charantia*** showed repellency effect against *An. stephensi* (Rajkumar & Jebanesan, 2007). Essential oil derived from leaves of ***Murraya paniculata*** revealed repellent activity against *Ae. aegypti*, *Ae. albopictus*, *An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). The volatile oil extracted from ***Myrica gale*** confirmed the repellent activity against the adults of *Ae. aegypti* (Blackwell et al., 2003). Essential oil derived from leaves of ***Myristica fragrans*** revealed repellent activity against the adults of *Ae. aegypti*, *Ae. albopictus*, *Anopheles dirus* and *Culex quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from ***Myrtus communis*** showed repellent activity against the adults of *Ae.* aegypti, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Essential oil derived from ***Nepeta cataria*** (Amer & Mehlhorn, 2006b), ***Nigella sativa*** (Prajapati et al., 2005) and ***Ocimum basilicum*** (Amer & Mehlhorn, 2006b and Prajapati et al., 2005) revealed repellent activity against the adults of *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus*.

Essential oil derived from ***Ocimum fischeri*** and ***Ocimum forskolei*** showed repellent activity against the adults of *An. gambiae* (Odalo et al., 2005). Essential oil derived from the leaves of ***O. tenuiflorum*** revealed repellent activity against the adults of *Ae. aegypti*, *Ae. albopictus*, *An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from the leaves of ***Ocimum selloi*** repelled the adults of *An. braziliensis*. Essential oil derived from ***Olea europaea*** revealed repellent activity against the adults of *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b).

Essential oil derived from ***Picea excelsa*** revealed repellent activity against the adults of *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oil derived from seeds of ***Pimpinella anisum*** showed repellent activity against the adults of *Cx. pipiens* (Erler et al., 2006). Essential oil derived from ***Pinus longifolia*** revealed repellent activity against the adults of *Cx. quinquefasciatus* and *An. culicifacies* (Ansari et al., 2005). Essential oil derived from ***Pinus pinea*** showed

repellent activity against the adults of *Cx. pipiens molestus* (Traboulsi et al., 2005).

Essential oil derived from ***Pinus roxburghii*** revealed repellent activity against the adults of *Cx. quinquefasciatus* and *Ae. aegypti* (Makhaik et al., 2005). Essential oil derived from ***Piper aduncum*** confirmed repellent activity against the adults of *Ae. albopictus* (Misni et al., 2009). Essential oils derived from the leaves of ***Piper betle*** and ***Piper nigrum*** revealed repellent activity against the adults of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil derived from fresh leaves of ***Plectranthes longipes*** and ***Plectranthes marrubioides*** showed repellent activity against the adults of *An. gambiae* (Odalo et al., 2005). Commercial oil derived from ***Pogostemon cablin*** revealed repellent activity against the adults of *An. dirus, Ae. aegypti* and *Cx. quinquefasciatus* (Trongtokit et al., 2005). Essential oil derived from shoots of ***Pimpinella anisum*** repelled the adults of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oil derived from leaves of ***Psidium guajava*** revealed repellent activity against *Ae. aegypti, Ae. albopictus, An. dirus, Cx. quinquefasciatus* (Tawatsin et al., 2006) and the adults of *An. stephensi* (Rajkumar & Jebanesan, 2007).

Essential oil of ***Rosmarinus officinalis*** revealed repellent activity against the adults of *Cx. pipiens pollens, An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati *et al.,* 2005 and Amer & Mehlhorn, 2006b). Essential oil derived from fresh leaves of ***Ruta chalepensis*** confirmed repellent activity against the adults of *Mansonia*. Essential oils derived from ***Salvia sclarea*** and ***Santalum album*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx quinquefasciatus* (Amer & Mehlhorn, 2006b).)

Essential oil derived from leaves of ***Schefflera leucantha*** revealed repellent activity against the adults of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx quinquefasciatus* (Tawatsin et al., 2006). Essential oil derived from fresh leaves of ***Solanum virginianum*** (Syn : *Solanum xanthocarpum*) showed repellent activity against the adults of *Cx. quinquefasciatus* (Rajkumar & Jebanesan, 2005). Commercial oil derived from ***Syzygium aromaticum*** showed repellent activity against the adults of *An. dirus, Ae. Aegypti, Cx. quinquefasciatus* (Trongtokit et al., 2005 and Makhaik et al., 2005).

Essential oil derived from ***Tagetes minuta*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Makhaik et al., 2005 and Amer & Mehlhorn, 2006b). Essential oils derived from fresh leaves of ***Tanacetum cineraraefolium*** (Syn : *Chrysanthemum cineraraefolium*) confirmed repellent activity against the adults of *Mansonia*. Essential oil derived from ***Tarchonanthus camphoratus*** and ***Tetradenia***

riparia revealed repellent activity against the adults of *An. gambiae* (Omolo et al., 2004). Essential oil of seeds of ***Trachyspermum ammi*** (Pandey et al., 2009) and **Tridax procumbens** (Rajkumar & Jebanesan, 2007) exhibited repellent activity against *An. stephensi*.

Essential oil derived from ***Thymus serpyllum*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oil derived from leaves of ***Tithonia diversifolia*** showed repellency against the adults of *An. gambiae, Ae. aegypti* and *Cx. quinquefasciatus* (Oyewole et al., 2008)

Essential oil derived from ***Viola odorata*** revealed repellent activity against the adults of *Ae. aegypti, An. stephensi and Cx. quinquefasciatus* (Amer & Mehlhorn, 2006b). Essential oils derived from leaves of ***Vitex trifolia*** revealed repellent activity against the adults of *Ae. aegypti, Ae. albopictus, An. dirus* and *Cx. quinquefasciatus* (Tawatsin et al., 2006).

Essential oil from ***Zanthoxylum beecheyanum*** fresh leaves showed repellent effect against *Culex pipens* (Peng et al., 2009). Essential oil derived from leaves of ***Zanthoxylum limonella*** showed repellent activity against the adults of *An. dirus, Ae. aegypti* and *Cx. quinquefasciatus* (Trongtokit et al., 2005). Essential oil derived from ***Zanthoxylum piperitum*** exhibited repellent effect against *Ae. aegypti* (Choochote et al., 2007). Volatile oil derived from ***Zingiber cassumunar*** showed repellent activity against *Ae. aegypti, An. minimus* and *Cx. quinquefasciatus* (Phasomkusolsil & Soonwera, 2010). Essential oil derived from the shoots of ***Zingiber officinale*** repelled the adults of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

5. Growth regulation

Essential oil from ***Boswellia serrata, Brassica campestris*** and ***Carum ptroselinum*** reduced the growth rate against *Cx. pipiens* larvae (Khater & Shalaby, 2007). Leaf and twig essential oils derived from ***Clausena excavata*** exhibited growth inhibiting activity against *Ae. aegypti* and *Ae. albopictus* (Cheng et al., 2009). Volatile oil derived from ***Cyperus esculentus, Eruca sativa*** and ***Trigonella foenum-greacum*** revealed growth regulating activity against the larvae *Cx. pipiens* (Khater & Shalaby, 2007).

6. Larvicidal activity

Essential oil derived from ***Acalypha segetalis*** showed larvicidal activity against mosquito spp. (Aboaba et al., 2010) and ***Achillea millefolium*** exhibited larvicidal activity against the larvae of *Ae. albopictus* (Conti et al., 2010). Essential oil derived from ***Ageratum conyzoides*** showed larvicidal

activity against the larvae of *Ae. aegypti* (Mendonca et al., 2005) and ***Allium sativum*** showed mortality against fourth instar larvae of *Cx. pipiens* (Zayed et al., 2009).

Essential oil derived from ***Amyris balsamifer, Anethum graveolens*** and ***Aniba rosaeodora*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. Aegypti, Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a), *Ae. Albopictus* and *Cx. pipiens pallens* (Zhu et al., 2006). Essential oil from ***Anacardium occidentale*** showed larvicidal activity against *Ae. aegypti* (Mendonca et al., 2005).

Essential oil derived from ***Anthemis nobilis*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***A. graveolens*** showed larvicidal activity against mosquito vectors of *Ae. aegypti* and *An. dirus* (Pitasawat et al., 2007).

Essential oil derived from ***Blumea mollis*** showed larvicidal activity against *Cx. quinquefasciatus* (SenthilKumar et al., 2008). Essential oil derived from ***Boswellia carteri*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Boswellia serrata*** and ***Brassica compestris*** showed larvicidal activity against *Cx. pipiens* (Khater & Shalaby, 2007). Essential oil derived from the aerial parts of ***Bupleurum fruticosum*** exhibited larvicidal activity against *Cx. pipiens* biotype molestus (Evergetis *et al.*, 2009).

Fixed oil from the seeds of ***Caesalpinia crista*** (Syn : *Caesalpinia bonduc*) showed larvicidal efficacy against *Cx. quinquefasciatus* (Saravanan *et al.*, 2007). Essential oil from ***Carapa guianensis*** showed larvicidal activity against the larvae of *Ae. aegypti* (Mendonca et al., 2005). Calamus oil showed larvicidal activity against *Cx. quinquefasciatus, Ae. aegypti* and *An. stephensi* (Manimaran et al., 2012).

Essential oil derived from ***Carum carvi*** (Caraway) caused larvicidal potential against mosquito vectors of *Ae. aegypti* and *An. dirus* (Pitasawat et al., 2007). Essential oil derived from ***Carum ptroselinum*** showed larvicidal activity against fourth larval instars of *Cx. pipiens* (Khater & Shalaby, 2007). Essential oil derived from ***Chamaemelum nobile*** and ***Cinnamomum camphora*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a).

Volatile oil from ***Cinnamomum*** spp. showed larvicidal activity against *Ae. albopictus, Ae. aegypti* and *Cx. pipiens pallens* (Zhu *et al.*, 2006). Essential oil derived from ***Citrus aurantium*** showed larvicidal activity

against *Ae. albopictus* (Akram *et al.*, 2010), *Cx. pipiens* (Melliou *et al.*, 2009), *Ae. aegypti* (Lee, 2006). Essential oil derived from ***Citrus grandis*** showed larvicidal activity against *Ae. albopictus* (Akram *et al.*, 2010).

Essential oils derived from ***Citrus hystrix*** exhibited larvicidal activity against *Ae. aegypti* (Sutthanont *et al.*, 2010). Essential oil derived from ***Citrus jambhiri*** showed larvicidal activity against *Ae. albopictus* (Akram et al., 2010). Essential oil derived from ***C. limon*** showed larvicidal activity against the third instar larvae of *Ae. albopictus* (Akram et al., 2010), *An. stephensi*, *Ae. Aegypti* (Cavalcanti et al., 2004), *Cx.* quinquefasciatus (Amer & Mehlhorn, 2006a) and *Cx. pipiens* fourth instar larvae (Zayed et al., 2009).

Essential oil derived from ***Citrus mitis, Citrus paradise, Citrus pseudolimon*** and ***Citrus reticulata*** showed larvicidal activity against *Ae. albopictus* (Akram et al., 2010). Essential oils derived from ***Citrus sinensis*** showed larvicidal activity against *Ae. aegypti* (Sutthanont et al., 2010 and Cavalcanti et al., 2004).

Leaf and twig essential oils from ***Clausena excavata*** exhibited larvicidal activity against *Ae. aegypti* and *Ae. albopictus* larvae (Cheng et al., 2009). Clove oil showed larvicidal activity against *Cx. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* (Manimaran et al., 2012).

Essential oil derived from the aerial parts of ***Conopodium capillifolium*** exhibited larvicidal activity against *Cx. pipiens* biotype molestus (Evergetis et al., 2009). Essential oil from ***Copaifera langsdorffii,*** (Mendonca et al., 2005), ***Cordia curassavica, Cordia leucomalloides*** (Santos et al., 2006), ***Croton argyrophulloides*** (Lima et al., 2006), ***C. argyrophyloides*** (Morais et al., 2006), ***Croton heliotropiifolius*** (Doria et al., 2010), ***Croton nepetaefolius*** (Lima et al., 2006 and Morais et al., 2006), ***Croton pulegiodorus*** (Doria et al., 2010), ***Croton sonderianus*** and ***Croton zehntneri*** (Lima et al., 2006 and Morais et al., 2006) showed larvicidal effect against the larvae of *Ae. Aegypti.*

Essential oil derived from seeds of ***Cuminum cyminum*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oil of ***Cuminum myrrha*** (Lee, 2006) and ***Curcuma aromatica*** (Choochote et al., 2005) caused larvicidal activity against the larvae of *Ae. aegypti*.

Essential oil derived from rhizomes of ***Curcuma longa*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005). Essential oil derived from ***Curcuma zedoaria*** (zedoary) caused larvicidal potential against mosquito vectors of *Ae. aegypti* and *An. dirus* (Pitasawat et al., 2007).

Essential oil derived from ***Cymbopogon citrates*** showed larvicidal activity against *Ae. aegypti* (Cavalcanti et al., 2004), *Cx. quinquefasciatus* (Pushpanathan et al., 2006) and the third instar larvae of *An. Stephensi* (Amer & Mehlhorn, 2006a).

Essential oil extracted from dried leaves of ***Cymbopogon proximus*** caused larvicidal activity against *Ae. aegypti, An. Gambiae*, and *An. arabiensis* (Bassole et al., 2003). Essential oil derived from ***Cyperus scariosus*** (Prajapati et al., 2005) and ***Cymbopogon winterianus*** (Amer & Mehlhorn, 2006a) showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus*. Essential oil derived from ***Cyperus esculentus*** showed larvicidal activity against fourth larval instars of *Cx. pipiens* (Khater & Shalaby, 2007).

Essential oil derived from the aerial parts of ***Elaeoselinum asclepium*** (Evergetis et al., 2009) and ***Eruca sativa*** (Khater & Shalaby, 2007) exhibited larvicidal activity against *Cx. pipiens*. Essential oil derived from ***Eucalyptus citriodora, Eucalyptus dives, E. globulus*** and ***Eucalyptus radiata*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a).

Essential oil derived from the forest redgum, ***Eucalyptus tereticornis*** caused larval mortality against first, second, third and fourth instars of *An. stephensi* (Senthil Nathan, 2007). Essential foliar oil derived from ***Eugenia melanadenia*** (Aguilera *et al.,* 2003) and ***Eugenia triquetra*** (Mora *et al.,* 2010) showed larvicidal activity against *Ae. aegypti*.

Essential oil derived from ***Ferula galbaniflua*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Foeniculum vulgare*** (fennel) caused larvicidal activity against mosquito vectors of *Ae. Aegypti, An. dirus* (Pitasawat et al., 2007) and *Ae. albopictus* (Conti et al., 2010). Essential oil derived from ***Glycine max*** and ***Glycine soja*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Guarea convergens, Guarea humaitensis, Guarea scabra*** and ***Guarea silvatica*** exhibited larvicidal activity against *Ae. Aegypti* (Magalhaes et al., 2010).

Essential oil derived from ***Helichrysum italicum*** showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. Aegypti, Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a) and against the larvae of *Ae. albopictus* (Conti et al., 2010). Essential oil derived from the aerial parts of ***Heracleum sphondylium*** subsp. ***pyrenaicum*** (Evergetis *et al.,* 2009) and

Hypericum scabrum (Cetin et al., 2011) exhibited larvicidal activity against *Cx. pipiens*.

Essential oil derived from the leaves of ***Hyptis fruticosa, Hyptis pectinata*** (Silva et al., 2008) and ***Hyptis suaveolens*** (Cavalcanti et al., 2004) showed larvicidal activity against *Ae. aegypti*. Essential oil extracted from ***Ipomoea cairica*** (Thomas et al., 2004) and ***Jasminum grandiflorum*** (Amer & Mehlhorn, 2006a) inflicted larvicidal activity against *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus*.

Cederwood oil from ***Juniperus*** spp. showed minimum larval mortality against the fourth instar larvae of *Cx. quinquefasciatus* and *Ae. aegypti* (Maheswaran et al., 2009). Essential oil derived from ***Juniperus communis, Juniperus virginiana*** (Amer & Mehlhorn, 2006a) and ***Juniperus macropoda*** (Prajapati et al., 2005) showed larvicidal activity against the third instar larvae of *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a).

Essential oils derived from ***Kaempferia galanga*** showed larvicidal activity against *Ae. aegypti* (Sutthanont et al., 2010). Essential oil extracted from ***Lavandula angustifolia*** exhibited larvicidal activity against the larvae of *Ae. albopictus* (Conti et al., 2010), the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a).

Essential oil derived from ***Lippia citriodora*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from the leaves of ***Lippia gracilis*** showed larvicidal activity against *Ae. aegypti* (Silva et al., 2008). Essential oils extracted from dried leaves of ***Lippia multiflora*** caused larvicidal activity against *Ae. aegypti*, *An. arabiensis* and *An. gambiae* (Bassole et al., 2003). Essential oil derived from ***Lippia polystachya*** showed larvicidal activity against *Cx. quinquefasciatus* (Gleiser & Zygadlo, 2007). Essential oil from ***Lippia sidoides*** showed larvicidal activity against the larvae of *Ae. aegypti* (Carvalho et al., 2003). Essential oil derived from ***Lippia turbinata*** showed larvicidal activity against *Cx. quinquefasciatus* (Gleiser & Zygadlo, 2007).

Essential oils derived from ***Litsea cubeba, Melaleuca leucadendron*** and ***Melaleuca quinquenervia*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Volatile oil derived from ***Melissa officinalis*** and ***Mentha longifolia*** showed larvicidal activity against *Cx. pipiens* larvae (Koliopoulos et al., 2010). Essential oil derived from fresh leaves of ***Mentha piperita*** showed larvicidal activity against the larvae of *An. annularis*, *An. culicifacies*, *Cx. quinquefasciatus* (Ansari et al., 2000), *An. Stephensi* and

Ae. aegypti (Amer & Mehlhorn, 2006a). Volatile oils derived from ***Mentha spicata*** and ***Mentha suaveolens*** showed larvicidal activity against *Cx. pipiens* larvae (Koliopoulos et al., 2010). Essential oil derived from ***Myrtus communis*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti*, *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a) and *Ae. albopictus* (Conti et al., 2010).

Catnip oil from ***Nepeta*** spp. showed larvicidal activity against *Ae. albopictus*, *Ae. aegypti*, *Cx. pipiens pallens* (Zhu et al., 2006), *An. Stephensi* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from seeds of ***Nigella sativa*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

Essential oil extracted from dried leaves of ***Ocimum americanum*** (syn: *O. canum*) caused larvicidal activity against *An. gambiae* complex, *An. arabiensis*, *An. gambiae* (Bassole et al., 2003) and *Ae. aegypti* (Cavalcanti et al., 2004). Essential oil derived from leaves of ***Ocimum basilicum*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005; Amer & Mehlhorn, 2006a and Nour et al., 2009). Essential oil derived from ***Ocimum gratissimum*** showed larvicidal activity against *Ae. aegypti* (Cavalcanti et al., 2004). Volatile oil derived from the aerial parts of ***Oenanthe pimpinelloides*** exhibited larvicidal activity against *Cx. pipiens* biotype molestus (Evergetis et al., 2009). Essential oil derived from ***Olea europaea*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oils derived from ***Origanum minutiflorum*** and ***Origanum onites*** showed larvicidal activity against *Cx. pipiens* (Cetin & Yanikoglu, 2006).

Essential oils from aerial parts of ***Pectis apodocephala*** and ***Pedis oligocephala*** exhibited larvicidal activity against *Ae. Aegypti* (Albuquerque *et al.*, 2007). Essential oil derived from ***Pelargonium graveolens*** and ***Picea excelsa*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil of ***Pimenta racemosa*** caused larvicidal activity against the larvae of *Ae. aegypti* (Lee, 2006). Essential oil derived from seeds of ***Pimpinella anisum*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapati et al., 2005).

Pine oil derived from ***Pinus longifolia*** showed larvicidal activity against *Ae. aegypti*, *An. culicifacies* and *Cx. quinquefasciatus* (Ansari et al., 2005). Hydro-distilled essential oil from Kenyan ***Piper capense*** exhibited larvicidal activity against the malaria vector, *An. gambiae* (Matasyoh et al., 2011).

Essential oil derived from leaves, stems and inflorescences of ***Piper marginatum*** showed larvicidal activity against *Ae. aegypti* (Autran et al., 2009). Essential oil derived from ***Piper nigrum*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Pistacia terebinthus*** exhibited larvicidal activity against the larvae *Cx. pipiens* (Cetin et al., 2011).

Essential oil derived from ***Plectranthes amboinicus*** exhibited larvicidal activity against *An. stephensi* (Senthilkumar & Venkatesalu, 2010). Volatile oil derived from ***Pluchea dioscoridis*** showed larvicidal activity against *Cx. pipiens* (Grace, 2002). Essential oil from ***Protium confusum*** (Santana et al., 2009) and ***Psidium rotundatum*** (Aguilera et al., 2003) showed larvicidal activity against *Ae. aegypti*.

Rosemary oil derived from shoots of ***Rosmarinus officinalis*** showed larvicidal activity against *An. stephensi*, *Ae. aegypti*, *Cx. quinquefasciatus* (Prajapati et al., 2005; Amer & Mehlhorn, 2006a and Maheswaran et al., 2009) and *Ae. albopictus* (Conti et al., 2010).

Volatile oils derived from ***Salvia fruticosa, Salvia pomifera*** subsp. ***calycina*** and ***Salvia pomifera*** subsp. ***pomifera*** showed larvicidal activity against *Cx. pipiens* larvae (Koliopoulos et al., 2010). Essential oils derived from ***Salvia sclarea*** and ***Santalum album*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oils derived from ***Satureja montana, Satureja parnassica*** subsp. ***parnassica*, Satureja spinosa, *Satureja thymbra*** (Michaelakis et al., 2007) and ***Seseli montanum*** subsp.***tomasinii*** (Evergetis et al., 2009) showed larvicidal effect against *Culex pipiens*. Essential oil derived from ***Syzygium aromaticum*** showed larval mortality against the fourth instar larvae of *Cx. quinquefasciatus* (Maheswaran et al., 2009) and *Ae. aegypti* (Maheswaran et al., 2009 and Sutthanont et al., 2010). Essential oils derived from ***Syzygium cumini*** (syn: Syzygium jambolana) showed larvicidal activity against *Ae. aegypti* (Cavalcanti et al., 2004).

Essential oil derived from ***Tanacetum coronarium*** (syn: *Chrysanthemum coronarium*) exhibited larvicidal activity against the larvae *Cx. Pipiens* (Cetin et al., 2011). Essential oil derived from ***Tagetes minuta*** (Amer & Mehlhorn, 2006a) and ***Tagetes patula*** (Dharmagadda et al., 2005) showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus*. Essential oil derived from ***Thymus*** spp. showed larvicidal activity against *Ae. albopictus*, *Ae. aegypti* and *Cx. pipiens pallens* (Zhu et al., 2006). Essential oil derived from ***Thymus serpyllum*** showed

larvicidal activity against the third instar larvae of *An.* stephensi, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Trigonella foenum-grecum*** showed larvicidal activity against fourth larval instars of *Cx. pipiens* (Khater & Shalaby, 2007).

Essential oil derived from ***Viola odorata*** showed larvicidal activity against the third instar larvae of *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Amer & Mehlhorn, 2006a). Essential oil derived from ***Vitex agnus castus*** exhibited larvicidal activity against the larvae of *Cx. pipiens* (Cetin et al., 2011).

Essential oil derived from ***Zanthoxylum armatum*** showed larvicidal activity against *Ae. aegypti, An. stephensi* and *Cx. quinquefasciatus* (Tiwary et al., 2007). Essential oil from ***Zanthoxylum beecheyanum*** fresh leaves showed larvicidal activity against *Cx. pipens* and *Cx. quinquefasciatus* (Peng et al., 2009). Essential oil derived from ***Zanthoxylum limonella*** (mullilam) caused larvicidal activity against mosquito vectors *Ae. aegypti* and *An. dirus* (Pitasawat et al., 2007). Essential oil derived from rhizomes of ***Zingiber officinale*** showed larvicidal activity against *An. stephensi, Ae. aegypti* (Prajapati et al., 2005) and *Cx. quinquefasciatus* (Prajapati et al., 2005 and Pushpanathan et al., 2008). Essential oil derived from ***Zingiber zerumbet*** caused larvicidal activity against *Ae. aegypti* (Sutthanont et al., 2010).

7. Adulticidal

Essential oil derived from ***Ajania tenuifolia*** exhibited adulticidal activity against *Cx. Pipiens* and *Cx. quinquefasciatus* (Yang et al., 2005). Junniferberry oil from ***Amelanchier*** spp. showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Apium graveolens*** showed adulticidal activity against *Ae. aegypti* (Chaiyasit et al., 2006). Neem oil from ***Azadirachta indica*** showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Calocedrus decurrens*** showed adulticidal activity against mosquitoes (McAllister & Adams, 2010).

Oil of ***Carum carvi*** seed revealed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009) and *Ae.* aegypti (Chaiyasit et al., 2006). Volatile oil of ***Chamomile roman*** exhibited adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Cinnamomum zeylanicum*** revealed adulticidal activity against *An. stephensi, Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Essential oil of **Cinnamomum** spp., Coriander oil from ***Coriandrum*** spp. and ***Citrus*** spp. exhibited adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009).

Essential oil derived from ***Cuminum cyminum*** revealed adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Volatile oil derived from ***Curcuma aromatica*** revealed adulticidal activity against *Ae. aegypti* (Choochote et al., 2005). Essential oil extracted from ***Curcuma longa*** showed adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Essential oil derived from ***Curcuma zedoaria*** showed adulticidal efficacy against *Ae.* aegypti (Chaiyasit et al., 2006).

Essential oil derived from ***Cymbopogon citrates*** exhibited adulticidal activity against *Cx. quinquefasciatus* (Yang et al., 2005), *Cx. pipiens pallens* (Kang et al., 2009). Essential oil of ***Cyperus scariosus*** showed adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Cardamom oil from ***Elettaria*** spp. inflicted adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil from ***Eucalyptus*** spp. showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009) and *An. stephensi* (Senthil Nathan, 2007). Essential oil of ***Eupatorium capillifolium*** revealed adulticidal activity against *Ae.* aegypti (Tabanca et al., 2010). Fennel oil from ***Foeniculum*** spp. inflicted adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009).

Essential oil derived from ***Illicium verum*** showed adulticidal efficacy against *Ae. aegypti* (Chaiyasit et al., 2006). Essential oil of ***Juniperus macropoda*** (Prajapathi et al., 2005) and ***Lantana camara*** leaves (Dua *et al.*, 2010) exhibited adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Lavender oil derived from ***Lavandula*** spp. caused adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Lippia polystachya*** and ***Lippia turbinata*** showed adulticidal activity against *Cx. quinquefasciatus* (Gleiser & Zygadlo, 2007).

Pennyroyal oil and Peppermint oil derived from ***Mentha*** spp. exhibited adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Mentha spicata*** exhibited adulticidal activity against *Cx. quinquefasciatus* (Yang et al., 2005). Essential oil of ***Nigella sativa*** revealed adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005).

Essential oil of ***Ocimum basilicum*** showed adulticidal activity against *An. stephensi*, *Ae. aegypti*, *Cx. quinquefasciatus* (Prajapathi et al., 2005) and *Cx. pipiens pallens* (Kang et al., 2009). Essential oil from ***Origanum marjorana*** (Majoram) and Patchouly oil from ***Pogostemon*** spp. showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009). Essential oil derived from ***Piper longum*** showed adulticidal activity against *Ae. aegypti* (Chaiyasit et al., 2006). Essential oil of ***Pimpinella anisum*** revealed adulticidal

activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Oil of Black pepper ***Piper*** spp. exhibited adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009).

Rosemary oil derived from ***Rosmarinus officinalis*** showed adulticidal activity against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* (Prajapathi et al., 2005). Rosemary oil derived from ***Rosmarinus*** spp., Sage oil from ***Salvia*** spp., Sandalwood oil from ***Santalum*** spp., Clove bud and leaf oil from ***Syzygium*** spp. and volatile oil from ***Melaleuca alternifolia*** showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009).

Essential oil from ***Thymusjsop*** showed adulticidal activity against *Cx. pipiens pallens* (Kang et al., 2009) and *Cx. quinquefasciatus* (Pavela et al., 2009). Essential oil from ***Zanthoxylum beecheyamum*** fresh leaves showed adulticidal effect against *Cx. pipens* and *Cx. quinquefasciatus* (Peng et al., 2009). Essential oil of ***Zingiber officinale*** showed adulticidal activity against *An. stephensi*, *Ae. aegypti*, *Cx. quinquefasciatus* (Prajapathi et al., 2005) and *Cx. pipiens pallens* (Kang et al., 2009).

8. Conclusion

Since the discovery of DDT, mosquito control has been almost completely based on synthetic organic insecticides. But the expensive use of synthetic organic insecticides during the past years has resulted in environmental pollution and in the development of physiological resistance in major vector species. Due to these drawbacks there has been a search for alternate methods of vector control especially by using natural plant derived substances.

The extracts from leaves, flowers and roots of plants and oils were found to have mosquito larvicidal activity, insect growth regulator activity, repellents and ovipositional deterrents (Sosan et al., 2001; Park et al., 2002; Pitasawat et al., 2007; Pavela, 2008; Arivoli et al., 2011 and Muthu *et al.*, 2012). In search of alternative and safe methods to protect from mosquito bites, products from essential oils are also emerging as good mosquito repellants and they are effective and safe at low cost.

9. References

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