MOSQUITO LARVICIDAL ACTIVITY OF PLANT ESSENTIAL OILS AND ESSENTIAL OIL COMPOUNDS

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Diseases transmitted by mosquitoes, such as malaria, dengue, dengue hemorrhagic fever, filariasis and Japanese encephalitis, remain as a severe public health problem in many tropical countries. The development of resistance by vector mosquitoes is reducing the effectiveness of current synthetic insecticides for example larvicides in mosquito control. Therefore, natural larvicides based on plant essential could be used as alternative mosquito larvicidal agents.

Even though there are previous reports on insecticidal properties of plant essential oils and their compounds, this is the first study on the mosquito larvicidal activity of essential oils of Ceylon *Cinnamomum zeylanicum* Blume, *Cymbopogon nardus* Rendle, *Cymbopogon citratus* DC and Sri Lankan varieties of *Eucalyptus microcorys*, *Eucalyptus grandis* and *Eucalyptus robusta* against local strains of *Culex quinquefasciatus* Say and *Aedes aegypti* L. In this study mosquito larvicidal activity of the leaf and bark oils of *C. zeylanicum* and the leaf oils of *C. nardus*, *C. citratus*, *E. microcorys*, *E. grandis* and *E. robusta* grown in Sri Lanka were evaluated and the mosquito larvicidal compounds from these oils were identified.

Essential oils of *E. microcorys*, *E. grandis* and *E. robusta* leaves were obtained by hydrodistillation, and ethanol extracts of *Eucalyptus* were prepared following standard protocols. Constitutional analysis of essential oils were carried out on a gas-liquid chromatography equipped with flame ionization detector. Mosquito larvicidal bio-assay of oils, extracts and compounds was carried out according to WHO guidelines against *Cx. quinquefasciatus* and *Ae. aegypti*. Active major compounds of *C. zeylanicum*, *C. nardus*, *C. citratus*, *E. microcorys*, *E. grandis* and *E. robusta* were identified through above bio-assay.

Cinnamomum zeylanicum bark oil showed more mosquito larvicidal activity against *Cx. quinquefasciatus* (LC_{50} = 25.5 mg l^{-1}) and *Ae. aegypti* (LC_{50} = 96.7 mg l^{-1}) than leaf oils of *C. zeylanicum*, *C. nardus*, *C. citratus* and *Eucalyptus*. *Cinnamomum zeylanicum* bark oil activity is superior to its compounds, cinnamaldehyde (LC_{50} = 30.2 mg l^{-1}), eugenol (LC_{50} = 38.1 mg l^{-1}) and other constituents of the oil against *Cx. quinquefasciatus*. *Cinnamomum zeylanicum* leaf oil showed more mosquito larvicidal activity (LC_{50} = 34.4 mg l^{-1}) than individual constituents of the oil, except cinnamaldehyde (LC_{50} = 30.2 mg l^{-1}) against *Cx. quinquefasciatus*. Major constituents of bark and leaf oils; i.e. cinnamaldehyde (LC_{50} = 90.1 mg l^{-1}) and eugenol (LC_{50} = 121.7 mg l^{-1}) showed more mosquito larvicidal activity against *Ae. aegypti* than their corresponding oils.

Leaf oil of *C. nardus* exhibited good mosquito larvicidal activity for *Cx. quinquefasciatus* (LC_{50} = 63.8 mg l^{-1}) and *Ae. aegypti* (LC_{50} = 102.9 mg l^{-1}) and activity is lower than its major constituents; citronellol, α-pinene and geraniol. Citronellol is more larvicidal against *Cx. quinquefasciatus* (LC_{50} = 48.8 mg l^{-1}) than major constituents of *C. nardus* oil. Geraniol showed more larvicidal activity against *Ae. aegypti* (LC_{50} = 100.5 mg l^{-1}) than citronellol, geranyl acetate, myrcene, α-terpineol and limonene, except α-pinene.

Cymbopogon citratus leaf oil showed moderate mosquito larvicidal activity against *Cx. quinquefasciatus* (LC_{50} = 64.8 mg l^{-1}) and it had less activity than its major constituents; citral and geraniol. Citral showed more larvicidal activity against *Cx. quinquefasciatus* (LC_{50} = 55.3 mg l^{-1}) and *Ae. aegypti* (LC_{50} = 99.8 mg l^{-1}) than geraniol, linalyl acetate, linalool and myrcene.

Among the *Eucalyptus* leaf essential oils tested *E. robusta* oil showed more mosquito larvicidal activity against *Cx. quinquefasciatus* (LC_{50} = 44.5 mg l^{-1}) *E. grandis* against *Ae. aegypti* (LC_{50} = 119.0 mg l^{-1}). α-Pinene is a major compound of leaf oils of *E. robusta* and *E. grandis* and this showed higher larvicidal activity against both mosquitoes tested in comparison to *Eucalyptus* oils. There is no considerable mosquito larvicidal activity found in ethanol extracts of *E. microcorys*, *E. grandis* and *E. robusta* leaves.

This study indicated that aromaticity of cinnamaldehyde, p-cymene, cinnamyl acetate and eugenol may have an enhancing effect on the mosquito larvicidal activity in above compounds. It appears that the position of the hydroxyl group, i.e. in the aromatic ring, in the cyclohexane ring or in the chain molecule, may influence the larvicidal activity

because activity of eugenol is more than geraniol, citronellol, linalool and α-terpineol against *Cx. quinquefasciatus*. This study also indicated that hydroxyl and aldehyde groups found in aromatic compounds could enhance the mosquito larvicidal activity. It also indicated that aldehyde group in the side chain of an aromatic compound such as cinnamaldehyde can enhance the larvicidal activity. The acetate group in aromatic ring may also increase the larvicidal activity comparison to acetate group in acyclic molecules. For example cinnamyl acetate showed more activity than linalyl acetate and geranyl acetate. Geraniol with less bulky ester group such as acetate tends to decrease the larvicidal activity against *Cx. quinquefasciatus*.

This study reveals that local varieties of bark and leaf oils of *C. zeylanicum* and leaf oils of *C. citratus*, *C. nardus*, *E. microcorys*, *E. grandis* and *E. robusta* could be developed to potential mosquito larvicidal agents against *Cx. quinquefasciatus* and *Ae. aegypti*. Several mosquito larvicidal compounds, i.e. cinnamaldehyde, eugenol, cinnamyl acetate, α-pinene, p-cymene, citral, geraniol and citronellol were identified and these compounds seem to be potential to be developed as mosquito larvicides after toxicological evaluations for vertebrates, including humans, and eco toxicological evaluations and commercial feasibility studies.