*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **4(10),** 16-21, October **(2015)** *Int. Res. J. Environment Sci.*

Efficacy of Phytochemicals as Sustainable Sources of Larvicidal Formulations for the Control of *Culex sitiens*

Rathy M.C.*, Sajith, U. and Harilal C.C.
Division of Environmental Science, Department of Botany, University of Calicut, Malappuram District, Kerala, 673635, INDIA

Available online at: www.isca.in, www.isca.me
Received 15th July 2015, revised 24th August 2015, accepted 30th September 2015

Abstract

Mosquitoes are significant group of arthropods in terms of public health, as they spread serious human diseases, causing millions of deaths every year and the development of resistance to chemical insecticides ensuing in rebounding vectorial competence. Controlling mosquitoes at the larval stage is easy as target specificity of the larvicides used can be ensured. Phytochemicals derived from the vast diversity of plant species are important sources of environmentally safe and biodegradable chemicals, which can aid in mosquito control. The present study has been outlined to assess the feasibility of using phytochemicals, as a larvicidal agent against third instar larvae of Culex sitiens. Twelve species of plants belonging to Zingiberaceae (2), Asclepiadaceae, Caricaceae, Myrtaceae (2), Rutaceae (2), Calophyllaceae, Annonaceae, Euphorbiaceae, Bignoniaceae families were screened for this purpose. Aqueous leaf extracts of selected plants were prepared (0.5, 1.0, 2.0, 4.0, and 8.0 ml) and tested against mosquito larvae reared from eggs under laboratory conditions, for a period of 6 hours.Mortality percentages and LC_{50} were calculated as per WHO protocols and standards. Of twelve plants studied, all the plant extracts infatuated significant larvicidal potential with LC_{50} values ranging from 1.31 to 4.79 mg/ml against the third instar larvae of Culex sitiens. Extracts from plants like Calotropis gigantea, Pimenta dioica, Curcuma longa, Polialthia longifolia, Saritaea magnifica, Ricinus communis, Alpinia galanga, Carica papaya, Murraya koenigii and Eucalyptus globulus have the highest potential to be used as an effective larvicidal agent, signifying an ecofriendly approach for the control of mosquito vectors. Further investigations would be desired to separate and make out the constituents responsible for larvicidal properties.

Keywords: Aqueous extracts, culex sitiens, mortality percentages, LC_{50}.

Introduction

Mosquitoes are the most imperious group of insects, adversely influencing the health status of human beings. They have a worldwide distribution and are involved in the transmission of many dreadful diseases affecting millions of people every year[1,2]. They do not only transmit parasites and pathogens but they also source of allergic reaction that includes local skin and systemic sensitivity[3,4]. Several mosquito species belonging to the genera *Anopheles*, *Culex* and *Aedes* are acting as vectors for many pathogenic organisms causing diseases like Malaria, Filariasis, and Japanese Encephalitis, Dengue fever, yellow fever etc. These diseases spread globally, causing high levels of human mortality and thereby acting as factors impedimenting the economic development of most of the developing countries across the world[5-8]. Two million people primarily in tropical countries are being at the risk of mosquito-borne diseases[9,10]. To prevent mosquito-borne diseases and reduce fatality, it is necessary to stumble on a method to control the mosquito population. For this substantiation many chemical insecticides were developed and used against the vector and with significant success, but it contains some distressing drawbacks like selectiveness and non-biodegradability which leads to toxic hazards to ecosystem, environment and human health[11]. So an alternative strategy needs to be overcome this problem. The plant based herbal insecticides are found to more efficient, safe and best substitute for chemical insecticides. Natural products of plant origin are safe to use than synthetic insecticides. Therefore biological and ecofriendly natural resources are broad search area for the control of mosquito vectors[12]. In this light, the present endeavor is designed to determine the efficiency of aqueous leaf extracts of plants belonging to varied taxonomic groups on *Culex sitiens* competent vector of Ross River Virus and Japanese encephalitis.

Material and Methods

Plant collection and processing: The selection of plants were carried out based on their local availability and reported medicinal properties. The materials were collected from the plants in field located in Botanical garden, University of Calicut. The materials were taken from healthy plants free from dust, dirt and other impurities and were fetched to the laboratory for subsequent procedure.

Preparation of extracts: The washed plant materials were chopped properly and kept in clean trays. For the preparation of extracts, approximately twenty grams (20gms) of plant material (Leaves) was taken and ground in a homogenizer using distilled water. The extract was filtered and the filtrate was made upto

1000 ml with distilled water and retained as stock solution for further experimentation. Serial dilutions of the stock solutions were prepared for assessing treatment efficiencies.

Collection and culture of mosquito species: Vector species *Culex sitiens* was selected for the present study. *Culex sitiens* commonly breeds in all impoundments, including pools, puddles, wells, ditches; as well as cement tanks, jars and cans. It is a competent vector of Ross River Virus and Japanese encephalitis[13]. This species is also involved in the transmission of filariasis (*Brugia malayi*), although only in a secondary role.

Mosquito larvae, collected from controlled breeding sites maintained with coconut shells, jars and cans kept at varying distances round households were used in the present study. Collected larvae were pooled in the laboratory and subjected to species level identification using standard manual[14].

In the laboratory, the larvae were transferred to enamel tray until adult emergence. After emergence, the mosquitoes were identified and species confirmed before rearing. Cyclic generations (two generations) of *Culex sitiens* were maintained and kept separately in mosquito cages in an insectary. For general rearing; mosquitoes were maintained at 26°C, 84% relative humidity, under a 16hr light and 8hr dark cycle with 1hr crepuscular period at the beginning and end of each light cycle based on the procedure of Kamaraj et al[15] with slight modification. The adult mosquitoes were fed on five percent glucose solution. For continuous maintenance of mosquito colony, the adult female mosquitoes were blood feud with artificial blood feeding membrane[16]. Ovitraps (Petridishes with tap water lined with filter paper) was placed inside the cages for egg laying[17]. The eggs laid were then transferred to enamel trays maintained in the larval rearing chamber. The larvae were fed with larval food (dog biscuits and yeast in the ratio 3:1)[18]. The larvae on becoming pupae were collected, transferred to plastic bowls and kept inside mosquito cages for adult emergence[19]

Larvicidal Bioassay: Bioassay for the larvicidal activity was carried out using WHO[20] procedure with minor modifications. Twenty numbers of early third instar larvae were introduced into treatment trays containing 250 ml of their natural growth media. To the treatment set, varying concentrations of the plant extracts (ie.0.5, 1.0, 2.0, 4.0 and 8.0 ml) were added from the stock solution; maintaining a relative concentration of the plant extracts as 10,20,40,80 and 160 mg/ml respectively. A control was also maintained for the treatment set. Mortality counts of larvae were monitored at regular intervals i.e.6, 12,24,48,72 and 96 hours after treatment and the control mortality as corrected using Abbott's[21] formula when the control mortality ranged between 5-20 percent[10,22-24].

$$\text{Percentage mortality} = \frac{\text{Number of dead larvae}}{\text{Number of larvae introduced}} \text{ X } 100$$

Statistical analysis: The mortality percentage was corrected using Abbott's[21] formula during the scrutiny of the larvicidal potentiality of the plant extracts. The experimental data was executed with MS Excel 2007 to find the Standard deviation and LC_{50} using probit analysis[25].

Results and Discussion

The toxicity of aqueous leaf extracts of twelve species of plants belonging to various families were experienced against third instar larvae of *Culex sitiens*. Details of plants used for the present study and mortality percentage of mosquito larvae noticed are depicted in table-1. The efficacy of various leaf extracts on *Culex sitiens* exposed to 96 hours, for confirming lethality as per WHO[19] standards are given Table 2.The data pertaining to LC_{50} are depicted in figure 1 and 2.

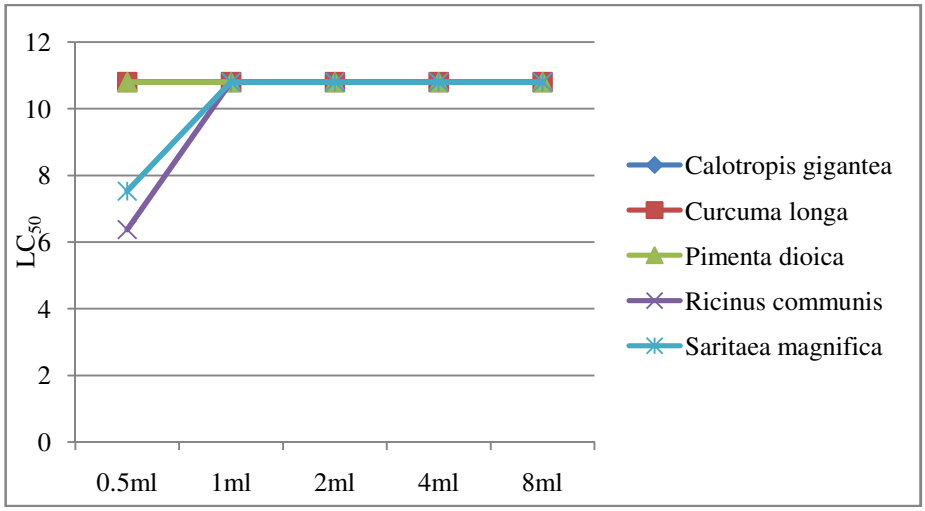

Figure-1
LC_{50} value of promising plant extract against *Culex sitiens*

Table-1
List of plant species used for the preparation of aqueous leaf extracts and their impact on *Culex sitiens* larvae

Name of plant	Family	Condition at which 100% larval mortality noticed
Alpinia galanga	Zingiberaceae	12hours in 80mg/ml
Calotropis gigantea	Apocynaceae	12hours in 10mg/ml
Carica papaya	Caricaceae	12 hours in 80mg/ml
Curcuma longa	Zingiberaceae	48 hours in 10 and 24 hours in20mg/ml
Eucalyptus globulus	Myrtaceae	96 hours in 40and72 hours in 80mg/ml
Glycosmis pentaphylla	Rutaceae	50% mortality at 96hrs 8ml
Mesua ferrea	Calophyllaceae	72 hours in 80mg/ml
Murraya koenigii	Rutaceae	12 hours in 80mg/ml
Pimenta dioica	Myrtaceae	12 hours in 20mg/ml
Polialthia longifolia	Annonaceae	12hours 20mg/ml
Ricinus communis,	Euphorbiaceae	24hours 20mg/ml
Saritaea magnifica	Bignoniaceae	12hours 160mg/ml and 24hours 20mg/ml

Table-2
The Efficacy of leaf extracts to the third instar larvae of *Culex sitiens*

Plants	Concentration of the extract (ml in 250 ml of growth medium)						Mean ± S.D
	Control	0.5	1	2	4	8	
Alpinia galanga	0	95	98.33	86.67	100	100	29.33±16.89
Calotropis gigantea	0	100	100	100	100	100	50±0
Carica papaya	0	26.67	55	100	100	100	27.83±18.25
Curcuma longa	0	100	100	100	100	100	43.33±8.17
Eucalyptus globulus	0	0	95	100	100	100	22.25±2.77
Glycosmis pentaphylla	0	0	0	0	0	56.67	13.64±11.82
Mesua ferrea	0	75	85	75	100	100	20.15±4.13
Murraya koenigii	0	0	0	46.67	100	100	18±15.14
Pimenta dioica	0	100	100	100	100	100	45.67±8.67
Polialthia longifolia	0	33.33	95	100	100	100	37.13±15.78
Ricinus communis,	0	70	100	100	100	100	31.33±4
Saritaea magnifica	0	91.67	100	100	100	100	36.11±7.03

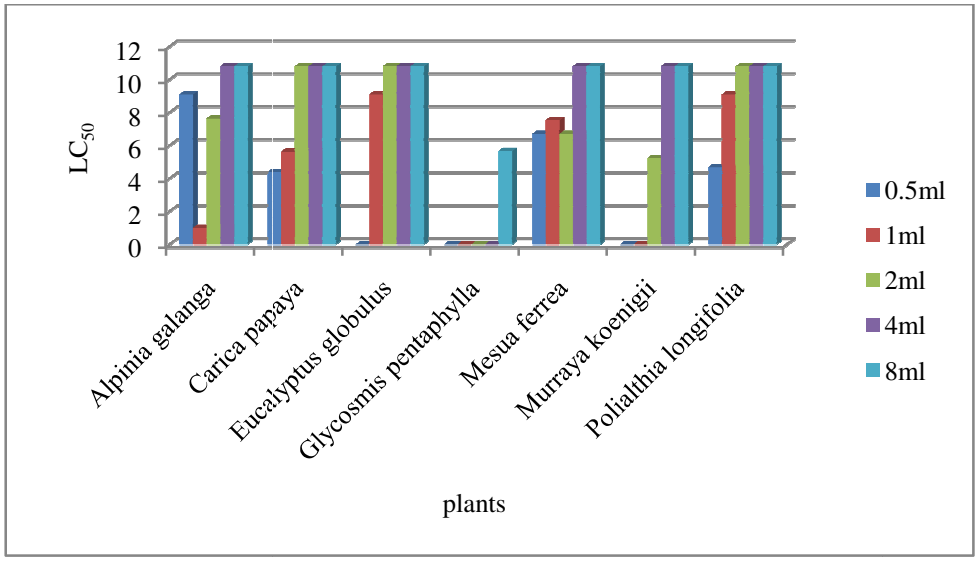

Figure-2
LC_{50} value of plant extract against *Culex sitiens*

Discussion: Mosquitoes are vectors for the pathogens of various diseases like malaria, Filariasis, Japanese encephalitis, Dengue, yellow fever, Chikungunya etc that causes high levels of morbidity and mortality[19]. So, one of the approaches for control of these mosquito-borne diseases is the interruption of disease transmission by killing or averting mosquitoes from biting human beings. The wide spread use of synthetic organic insecticides during the last five decades has upshoted in environmental hazards and development of resistance in the major vector species[26,27]. This has demanded the search for herbal preparations that do not produce any adverse effects in the nontarget organisms and are easily biodegradable remains a top research issue for scientists associated with alternative vector control[6,28,29]. Phytochemicals may serve as suitable alternatives to synthetic insecticides in future as they are relatively safe, inexpensive and are readily available throughout of the world[26]. In fact, many researchers have reported the effectiveness of plant extracts and isolated components tested against different species of mosquito[28,30,31].

The larvicidal activity of different crude solvent (hexane, ethyl acetate, and methanol) extracts of plants like *Aristolochia indica, Cassia angustifolia, Diospyros melanoxylon, Dolichos biflorus, Gymnema sylvestre, Justicia procumbens, Mimosa pudica, Zingiber zerumbet* against adult and early fourth instar larvae of *Culex quinquefasciatus* and *Culex gelidus* were experimented by Kamaraj etal[32]. Vahitha et al[33,34] worked out the larvicidal efficacy of methanol leaf extracts of *Pavonia zeylanica* and *Acacia ferruginea* were tested against the late third instar larvae of *Culex quinquefasciatus* with LC50 values of 2,214.7 and 5,362.6 ppm, respectively.

The toxicity of crude extracts from the *Ricinus communis* against fourth instar larvae *Anopheles arabiensis* and *Culex quinquefasciatus*. The LC_{50} values of 2nd, 3rd and 4th instar larvae of *Anopheles arabiensis* and *Culex quinquefasciatus* are 403.65, 445.66 and 498.88ppm, 1091.44, 1364.58 and 1445.44ppm respectively were reported by Elimam et al[35]. Singh et al[36,37] reported that the LC_{50} values of crude aqueous and hexane extracts of *Momordica charantia* against *Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti* mosquito larvae are 0.50, 1.29, and 1.45% (aqueous extracts) and 66.05, 96.11, and 122.45ppm (hexane extracts), respectively. The monotonous observations carried out by various researchers in the field of mosquito control by plants.

In the present endeavor the effect of the leaf extracts of *Alpinia galanga*, *Calotropis gigantea*, *Carica Papaya*, *Curcuma longa*, *Eucalyptus globulus*, *Glycosmis pentaphylla*, *Mesua ferrea*, *Murraya koenigii*, *Pimenta dioica*, *Polialthia longifolia*, *Ricinus communis* and *Saritaea magnifica* were tested against the third instar larvae of *Culex sitiens* at varying concentrations. All plant extracts showed utmost larvicidal effects after 96 hours. However, the highest larval mortality was found with leaf extracts of *Calotropis gigantea* (50±0), *Curcuma longa* (43.33±8.17), *Pimenta dioica* (45.67±8.67), *Saritaea magnifica* (36.11±7.03) *and Ricinus communis* (31.33±4) against the third instar larvae of *Culex sitiens* (table-2).

The present investigation revealed that the aqueous extract of *Calotropis gigantea* (Leaf) was the most efficient, divulging a substantial LC_{50} value of 10.8 mg/ml. But the leaf extract of *Glycosmis pentaphylla* was least efficient with an LC_{50} value of 5.66 mg/ml (figure-1 and 2). It was also noticed that the extracts made from *Calotropis gigantea*, *Curcuma longa*, *Pimenta dioica*, *Ricinus communis* and *Saritaea magnifica* obsessed important larvicidal potential with LC_{50} values ranging from 1.01 to 10.8 mg/ml (Figure 1).Other extracts (*Alpinia galanga, Carica papaya, Mesua ferrea, Murraya koenigii, Polialthia longifolia,* and *Eucalyptus globulus*) showed only moderate

toxicity against *Culex sitiens* larvae (figure-2).

Conclusion

A Study has been undertaken to assess the efficiency of phytochemicals derived from selected plants as potential and sustainable sources of larvicidal agents for the management of mosquito vectors. Twelve plant species belonging to Zingiberaceae (2), Asclepiadaceae, Caricaceae, Myrtaceae (2), Rutaceae (2), Calophyllaceae, Annonaceae, Euphorbiaceae, Bignoniaceae, families were screened for this purpose. Aqueous leaf extracts of selected plants were prepared (0.5, 1.0, 2.0, 4.0 and 8.0 ml) and tested against mosquito larvae reared from eggs under laboratory conditions, for a period of 96hours. Mortality percentages and LC_{50} were calculated as per WHO protocols and standards. Extracts from plants like *Calotropis gigantea, Pimenta dioica, Curcuma longa, Polialthia longifolia, Saritaea magnifica, Ricinus communis, Alpinia galanga, Carica papaya, Murraya koenigii,* and *Eucalyptus globulus* were noted to be lethal to the larvae. It can be concluded that these plants can be treated as source of phytochemicals for the control of mosquitoes. Isolation of the active components from these plants substantiates useful in the development of safer bio-insecticides in future.

Acknowledgement

The authors are thankful to acknowledge the financial support of the Directorate of Climate change (DoECC), Government of Kerala.

References

1. Sajith U., Rathy M.C. and Harilal C.C., Diversity assessment of mosquitoes with reference to the occurrence of vector borne diseases in Thalassery municipal area of Malabar Coast, Kerala, India, *International Journal of Development Research*, **5(6),** 4592-4594 **(2015)**

2. Dohutia C., Bhattacharyya D.R., Sharma S.K., Mohapatra P.K., Bhattacharjee K., Gogoi K., Gogoi P., Mahanta J. and Prakash A., Larvicidal activity of few select indigenous plants of North East India against disease vector mosquitoes (Diptera: Culicidae), *Tropical Biomedicine,* **32(1),** 17–23 **(2015)**

3. Pedro M Gutierrez. Jr., Aubrey N Antepuesto, Bryle Adrian, Eugenio L and Maria Fleurellei L Santos, Larvicidal Activity of Selected Plant Extracts against the Dengue vector *Aedes aegypti* Mosquito, *International Research Journal of Biological sciences*, **3(4),** 23-32 **(2014)**

4. Govindarajan M., Mathivanan T., Elumalai K., Krishnappa K and Anandan A., Mosquito larvicidal, ovicidal, and repellent properties of botanical extracts against *Anopheles stephensi, Aedes aegypti,* and *Culex quinquefasciatus* (Diptera: Culicidae), *Parasitol Res,* **109,** 353–367 **(2011)**

5. Rathy M.C., Sajith U. and Harilal C.C., Plant diversity for mosquito control: A preliminary study, *International Journal of Mosquito Research*, **2(1),** 29-33 **(2015)**

6. Nisha Mathew, Anitha M.G., Bala T.S.L., Sivakumar S.M., Narmadha R. and Kalyanasundaram M., Larvicidal activity of *Saraca indica*, *Nyctanthes arbor-tristis* and *Clitoria ternatea* extracts against three mosquito vector species, *Parasitol Res*, **104,** 1017-1025 **(2009)**

7. Chellaiah Muthu, Appadurai Daniel Reegan, Selvadurai Kingsley and Savarimuthu Ignacimuthu, Larvicidal activity of pectolinaringenin from *Clerodendrum phlomidis* L. against *Culex quinquefasciatus* Say and *Aedes aegypti* L. (Diptera: Culicidae) *Parasitol Res,* **111,** 1059–1065 **(2012)**

8. Sheik Jahabar Ali H and Annamalai K., Mosquito larvicidal Activity of *Anisomilous malabarica* (Linn) R.Br. (Family: Asteraceae) Against *Culex tritaeniorhynchus* Giles and *Anopheles subpictus* Grassi (Diptera: Culicidae), *International Journal of Environmental Biology*, **3(4), 203-207 (2013)**

9. Service M., *Medical Entomology for students*, 3rd ed. Cambridge University Press, Cambridge, **(2004)**

10. Arivoli S., Samuel Tennyson and Jesudoss Martin J., Larvicidal efficacy of *Vernonia cinerea* (L.) (Asteraceae) leaf extracts against the filarial vector *Culex quinquefasciatus* Say (Diptera: Culicidae), *Journal of Biopesticides*, **4(1), 7-42 (2011)**

11. Anushree Singha Ray., Kuntal Bhattacharya., Aniket Singh and Goutam Chandra., Larvicidal Activity of *Nelumbo nucifera* Gaertn. (Nymphaeaceae) against *Anopheles stephensi* (Liston 1901) and its Effect on Non-target Organisms, *Journal of Mosquito Research*, **4(10), 1-7 (2014)**

12. Mousumi Kundu., Anjali Rawani and Goutam Chandra, Evaluation of Mosquito Larvicidal Activities of Seed Coat Extract of *Cassia sophera* L., *Journal of Mosquito Research*, **3(11), 76-81 (2013)**

13. Tanya L Russell., Michael D Brown., David M Purdie., Peter A Ryan and Brian H Kay, Efficacy of Vecto Bac. (*Bacillus thuringiensis* variety *israelensis*) Formulations for Mosquito Control in Australia, *Journal of Economic Entomology*, **96(6),** 1786-1791 **(2003)**

14. Barraud P.J., The Fauna of British India, including Ceylon and Burma, Diptera., Vol. V, Family Culicidae, Tribes Megarhini and Culicini, Taylor and Francis, London, **(1934)**

15. Kamaraj C., Bagavan A., Elango G., Abduz Zahir A., Rajakumar G., Marimuthu S., Santhoshkumar T and Abdul Rahuman A., Larvicidal activity of medicinal

plant extracts against *Anopheles subpictus* and *Culex tritaeniorhynchus*, *Indian J Med Res*, **134,** 101-106 **(2011)**

16. Mishra K., Kumar Raj D., Hazra R.K. and Dash A.P., A simple, artificial-membrane feeding method for the radio-isotope labelling of *Aedes aegypti* polypeptides in vivo, *Ann Trop Med Parasitol*, **99,** 803-806 **(2005)**

17. Abdul Rahuman A., Geetha Gopalakrishnan., Venkatesan P and Kannappan Geetha, Larvicidal activity of some Euphorbiaceae plant extracts against *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae), *Parasitol Res*, **102,** 867–873 **(2008)**

18. Syoziro Asahina, Food Material and Feeding Procedures for Mosquito Larvae, *Bull. Org. mond. Sante Bull. Wld Hlth Org*, **31,** 465-466 **(1964)**

19. Raveen R., Dhayanidhi P., Dhinamala K., Arivoli S and Samuel Tennyson., Larvicidal activity of *Pedilanthus tithymaloides* (L.) Poit (Euphorbiaceae) Leaf against the dengue vector *Aedes aegypti* (L.) (Diptera: Culicidae), *International Journal of Environmental Biology,* **2(2),** 36-40 **(2012)**

20. WHO, Technical Report Series: WHO/VB/81, 807 **(1981)**

21. Abbott W.S., A method of computing the effectiveness of an insecticide, *Journal of Economic Entomology*, **18,** 265-267 **(1925)**

22. Arti Prasad and Esha Sharma, Phytotoxicological assessment of *Moringa oleifera* Lam. against larvae of important human malaria vector *Anopheles stephensi* Liston (Insecta:Diptera:Culicidae), *International Journal of Innovation and Applied Studies*,**7(4),** 1633-1641 **(2014)**

23. Kadarkarai Murugan, Biolarvicidal and pupicidal activity of Acalypha alnifolia Klein ex Willd. (Family: Euphorbiaceae) leaf extract and Microbial insecticide, Metarhizium anisopliae (Metsch.) against malaria fever mosquito, Anopheles stephensi Liston. (Diptera:Culicidae), *Parasitology Research*, **110,** 2263–2270 **(2012)**

24. Angajala Gangadhara., Pasupala Pavan and Subashini R, One-step biofabrication of copper nanoparticles from Aegle marmelos correa aqueous leaf extract and evaluation of its anti-inflammatory and mosquito larvicidal efficacy, *RSC Advances*, **93(4)**, 51459-51470 **(2014)**

25. Finney D.J., Probit analysis, Cambridge University Press, London, **(1971)**

26. Govindarajan M., Sivakumar R., Rajeswari M. and Yogalakshmi K., Chemical composition and larvicidal activity of essential oil from Mentha spicata (Linn.) against three mosquito species, *Parasitology Res*, **110,** 2023–2032 **(2012)**

27. Barbara Conti., Angelo Canale., Alessandra Bertoli, Francesca Gozzini and Luisa Pistelli, Essential oil composition and larvicidal activity of six Mediterranean aromatic plants against the mosquito Aedes albopictus (Diptera: Culicidae), *Parasitology Res,* **107**, 1455–1461 **(2010)**

28. Raheli Neema M., Ojunga M and Ramesh F, The Larvicidal activity of *Indigofera arrecta* leaf extract against *Culex* mosquito larvae, *International Journal of Bioassays*, **4(01),** 3666-3669 **(2015)**

29. Mittal P.K. and Subbarao S.K., Prospects of using herbal products in the control of mosquito vectors, *ICMR Bull*, **33,** 1–10 **(2003)**

30. Sukumar K., Perich M. J. and Boober L.R., Botanical derivatives in Mosquito Control: A Review, *J. Am. Mosq. Contr. Assoc.,* **7,** 210-237 **(1991)**

31. Kalyanasundaram M and Das P.K., Larvicidal Synergic Activity of plant Extract for Mosquito Control, *Ind. J. Med. Res.,* **82,** 19-23 **(1985)**

32. Chinnaperumal Kamaraj, Abdul Abdul Rahuman, Anita Mahapatra, Asokan Bagavan and Gandhi Elango, Insecticidal and larvicidal activities of medicinal plant extracts against mosquitoes, *Parasitol Res,* **107,** 1337–1349 **(2010)**

33. Vahitha R., Venkatachalam M.R and Jebanesan A., Larvicidal efficacy of *Pavonia zeylanica* L. and *Acacia ferruginea* D.C. against *Culex quinquefasciatus* Say, *Bioresource Technology,* **82(2),** 203-204 **(2002)**

34. Sarita Kumar, NaimWahab, Monika Mishra and RadhikaWarikoo, Evaluation of 15 local plant species as larvicidal agents against an Indian strain of dengue fever mosquito, Aedes aegypti L. (Diptera: Culicidae), *Frontiers in Physiology,* **104(3),** 1-6 **(2012)**

35. Elimam A.M., Elmalik K.H. and Ali F.S., Larvicidal, adult emergence inhibition and oviposition deterrent effects of foliage extract from *Ricinus communis* L. against *Anopheles arabiensis* and *Culex quinquefasciatus* in Sudan, *Trop. Biomed.*, **26,** 130–139 **(2009)**

36. Singh R.K., Dhiman R.C. and Mittal P.K., Mosquito larvicidal properties of *Momordica charantia* Linn (family: Cucurbitaceae), *J.Vector Borne Dis.*, **43,** 88–91 **(2006)**

37. Omar Ali Mondal, Ataur Rahman Khan and Nurul Islam, Larvicidal potentiality of *Derris indica* Bennet, extracts against *Culex quinquefasciatus* say (diptera: culicidae) larvae, *Bangladesh J. Zool.,* **39(2),** 137-145 **(2011)**