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Research Article

REPELLENT PROPERTY OF PLANTS AGAINST MOSQUITOES IN FIELD CONDITIONS BY TRADITIONAL METHOD

Samuel, T.[1*], Kalarani, A.[1], Vinodha, V.[1], Arivoli, S.[2], Selvakumar, S.[3], Meeran, M.[4] and Syedalifathima, A.[4]

[1]Department of Zoology, Madras Christian College, Chennai 600 059, Tamil Nadu, India
[2]Department of Zoology, Thiruvalluvar University, Vellore 632 115, Tamil Nadu, India
[3]Department of Vector Control, Greater Chennai Corporation, Chennai 600 003, Tamil Nadu, India
[4]Department of Zoology, Hajee Karutha Rowther Howdia College, Uthamapalayam 625 533, Theni, Tamil Nadu, India

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ABSTRACT

Repellent property of plants, *viz.*, *Azadirachta indica*, *Calotropis gigantea*, *Coriandrum sativum*, *Eucalyptus globulus*, *Mentha spicata*, *Murraya koenigii*, *Ocimum tenuiflorum*, *Phyllanthus acidus*, *Ricinus communis* and *Vitex negundo* were studied under natural conditions in the field making use of the traditional knowledge as background. The study area was selected based on assessment of mosquito density irrespective of species in natural/domestic habitats. Field observations were undertaken in houses wherein dried powdered leaves of each plant were burned on glowing charcoal which produced smoke and acted as a repellent mosquitocide. Overall results indicated that among the plants utilized, the order of highest repellence with protection time was observed in *Mentha spicata* (12 hours) < *Ocimum tenuiflorum* < *Ricinus communis* (11 hours) < *Azadirachta indica* < *Coriandrum sativum* < *Vitex negundo* (10 hours) < *Calotropis gigantea* (9 hours) < *Eucalyptus globulus* (8 hours) < *Phyllanthus acidus* (7 hours) < *Murraya koenigii* (6 hours). Besides these, the incidence of mosquito bites significantly reduced after usage of plant products. It may be concluded that natural products from plants of insecticidal and medicinal values have higher efficiency in reducing mosquito menace due to their repellent toxicity. Further studies on the in-depth field bioassays are needed as the present study indicated the scope to use local plants to control and repel mosquitoes.

Keywords: Mosquitoes, Plants, Repellent Property, Traditional method.

INTRODUCTION

Mankind and mosquitoes must have lived in close association since our ancestors first evolved as they are a serious threat to public health transmitting several dangerous diseases for over two billion people in the tropics. Personal protection from mosquito bites by application of repellent is viewed as critical "public health tool", in reducing the transmission of mosquito-borne diseases and irritating bites (Osimitz & Grothaus, 1995; Fatope *et al*., 1993). Repellents are used as personal protection methods against biting arthropods with a major aim of avoiding nuisance (Trigg, 1996) and as one of the most effective tools for protecting human from vector-borne diseases and nuisance caused by mosquitoes (Barnard, 2005; Curtis *et al*., 1990; Gupta *et al*., 1989). Repellence, the "gold standard" N, N-diethyl 1-3-methyl benzamide (DEET), has shown significant repellency against mosquitoes and other biting arthropods (Walker *et al*., 1996). However, toxicity reactions for humans after DEET application can be severe (Qiu *et al*., 1998; Robbins & Cherniack, 1986). To avoid these adverse effects, many research works have been carried out to replace DEET with repellents that are derived from plants.

Plants were first recorded being used against biting insects by the ancient Greeks and are still used by enormous numbers of people today. Plant products can be used as repellents for protection against mosquito bites, depending on the type of activity they possess (Mittal, 2003) since they constitute a rich source of bioactive chemicals (Wink, 1993). Many species in the plant

*Corresponding Author: Dr. Samuel Tennyson, Assistant Professor, Department of Zoology, Madras Christian College, Chennai 600 059, Tamil Nadu, India, Email: samtennyson@gmail.com, Mobile: +91 9884116135

kingdom synthesize a variety of secondary metabolites which play a vital role in defence of plants against insects/mosquitoes. Phytochemicals obtained from plants are usually less environmentally harmful than synthetic chemicals and it has renewed the interest in the research on these compounds, considering them as an ecologically safe alternative for synthetic insecticides (Isman, 2006). A review of botanical phytochemicals with mosquitocidal potential published by Shaalan *et al*., (2005) demonstrates the identification of novel effective mosquitocidals from botanicals containing active phytochemicals. Most households in the developing world rely on personal protection measures of limited effectiveness, *viz*., burning mosquito coils or leaves, despite the wide range of effective vector control measures available. Keeping in view of this traditional knowledge, the present study was conducted to test the mosquito repellent efficacy of local plants in field conditions.

MATERIALS AND METHODS

The details of plants selected based on available literature, abundant availability, medicinal and insecticidal properties for this study are presented in Table 1. The leaves of these plants were collected in and around Chennai, Tamil Nadu, India, brought to the laboratory, washed with dechlorinated water, shade dried under room temperature and was then powdered individually. The repellent activity was studied under natural conditions in the field. The field study was undertaken in Mangalapuram 13th Street, Chetpet, Chennai, Tamil Nadu, India (13.0730° N, 80.2450° E) based on the assessment of mosquito density (irrespective of species) status in the natural/domestic habitats during dusk which involved direct observations. A total of twelve houses were selected of which ten were used for treatment and were marked as (H1 to H10). Kazembe & Nkomo (2010) methodology with minor modifications was adopted for the present study wherein the powdered plant leaves were burned on glowing charcoal which produces smoke and thereby acts as a repellent to mosquitoes. In each of the ten houses selected for treatment, the powdered leaves of each plant (250g) were burned on glowing charcoal. The burning of plant leaves was changed in a cyclic manner to avoid bias during each trial. The house treated with burning of charcoal only served as treated control and the house as untreated control did not receive any treatment including charcoal. The experimental set up was kept out of reach of children and use of mosquito repellents was discouraged during the period of study. A total of ten trials were conducted and the protection time (in hours) was recorded at the end of each trial (18.00 – 06.00 hours) which was used to highlight the efficacy of the plant used. Prior to the start of the experiment, pre-treatment questionnaires were distributed to people to evaluate the status of nuisance caused by the mosquitoes to the people residing in the houses where the experiment was conducted and likewise a post-treatment questionnaire after the experiment.

RESULTS AND DISCUSSION

The present study indicated that the incidence of mosquito bites significantly reduced after usage of plant products. Maximum of twelve hours protection time was recorded as the highest protection time. The experimental house 1 highlighted *Mentha spicata* to give the maximum repellence of twelve hours and *Murrya koenigii* provided minimum repellence with low protection time of five hours. In the case of house 2, *Mentha spicata* showed maximum protection time while *Ocimum tenuiflorum* and *Phyllanthus acidus* recorded a low protection time of six hours. In house 3, maximum protection time was liberated by *Coriandrum sativum*, *Mentha spicata*, *Ocimum tenuiflorum* and *Phyllanthus acidus* whereas *Eucalyptus globulus* and *Vitex negundo* gave a minimum protection time of nine hours. In house 4, *Vitex negundo* yielded the maximum protection time whereas *Ocimum tenuiflorum* gave eight hours of protection as minimum repellence. For house 5, maximum repellence was provided by *Mentha spicata* and minimum repellence of six hours protection time by *Murraya koenigii*. In house 6, *Coriandrum sativum*, *Eucalyptus globulus*, *Ocimum tenuiflorum* and *Vitex negundo* provided maximum repellence while *Murraya koenigii* with lowest repellence of six hours. In the case of house 7, *Azadirachta indica* and *Eucalyptus globulus* recorded the maximum repellence whereas *Murraya koenigii* provided six hours as minimum repellence. In house 8, *Azadirachta indica*, *Coriandrum sativum* and *Ocimum tenuiflorum* provided the highest protection time while *Murraya koenigii* the lowest protection time of seven hours. In the case of house 9, the maximum protection time was provided by *Calotropis gigantea*, *Coriandrum sativum*, *Mentha spicata*, *Phyllanthus acidus* and *Vitex negundo*, and lowest protection time of eight hours by *Azadirachta indica*, *Murraya koenigii* and *Ocimum tenuiflorum*. For house 10, *Ocimum tenuiflorum* and *Vitex negundo* delivered maximum repellence while *Calotropis gigantea*, *Murraya koenigii* and *Phyllanthus acidus* the lowest repellence with eight hours. Amongst all the plants tested, the overall order of highest repellence was observed in *Mentha spicata* < *Ocimum tenuiflorum* < *Ricinus communis* < *Azadirachta indica* < *Coriandrum sativum* < *Vitex negundo* < *Calotropis gigantea* < *Eucalyptus globulus* < *Phyllanthus acidus* < *Murraya koenigii* (Figure 1). The house which served as treated control provided a protection time of 28 minutes and no repellence against mosquitoes was observed in the house taken up as untreated control. Further in addition to the experimental data, the feedback response projected in the pre and post treatment questionnaire from the people/community residing in the houses where the repellent experiment/study was conducted served as supportive evidence as there was a gradual decrease in the mosquito bites and nuisance.

Botanicals have widespread insecticidal and repellent properties and will work as suitable alternative products to fight mosquitoes. Though various plants have been reported to possess repellent activity against mosquitoes (Sukumar *et al*., 1991), *Azadirachta indica*, *Eucalyptus* sp., *Lantana camara*, *Cymbopogon* sp., *Mentha piperita*, *Tagetes minuta*

and some other plant products have been studied more extensively during the past one decade. The results of the present study corroborate with the findings of (Shankar *et al*., 2013) who tested the repellent activity of local plants by burning dry leaves to produce smoke which acted as a repellent to drive away the mosquitoes. In the present study, *Mentha spicata* was found to exhibit a maximum repellence with a protection time of 12 hours, which showed more protection time than that of *Azadirachta indica*, *Murrya koenigii* and *Citrus medica* with six hours protection time (Shankar *et al*., 2013) under field condition.

Plants from the Lamiaceae family are used commonly in East and West Africa as mosquito repellents (Kokwaro, 1976; Dalziel, 1937). Many species of the Lamiaceae are strongly aromatic and toxic to insects (Pålsson & Jaenson, 1999)and this was also observed in the present study. In Zimbabwe, *Ocimum* sp. leaves are rubbed on the skin as a method of repelling mosquitoes (Lukwa, 1994). In India, in the state of Maharashtra, the tribal people use smoke from the leaves of *Vitex negundo* to protect them from mosquito bites at night (Hebbalkar *et al*., 1992). Members of the Lamiaceae are also frequently burnt as protection from mosquitoes throughout Africa. In Sri Lanka, Holy basil (*Ocimum sanctum*), is commonly burned, to repel mosquitoes (Silva, 1991). All these reports are corroborated to the present study.

Table 1. Details of plant utilized for the repellent study.

Plant name	Vernacular name (Tamil)	Scientific name	Family
Neem	Veppai	*Azadirachta indica* (AI)	Meliaceae
Milkweed	Erukku	*Calotropis gigantea* (CG)	Apocynaceae
Coriander	Kotthumalli	*Coriandrum sativum* (CS)	Apiaceae
Blue gum	Kaurpuramaram	*Eucalyptus globulus* (EG)	Myrtaceae
Spearmint	Pudina	*Mentha spicata* (MS)	Lamiaceae
Curry tree	Kariveppilai	*Murraya koenigii* (MK)	Rutaceae
Holy basil	Tulsi	*Ocimum tenuiflorum* (OT)	Lamiaceae
Star gooseberry	Aranelli	*Phyllanthus acidus* (PA)	Phyllanthaceae
Castor	Amanakku	*Ricinus communis* (RC)	Euphorbiaceae
Chaste tree	Nocchi	*Vitex negundo* (VN)	Lamiaceae

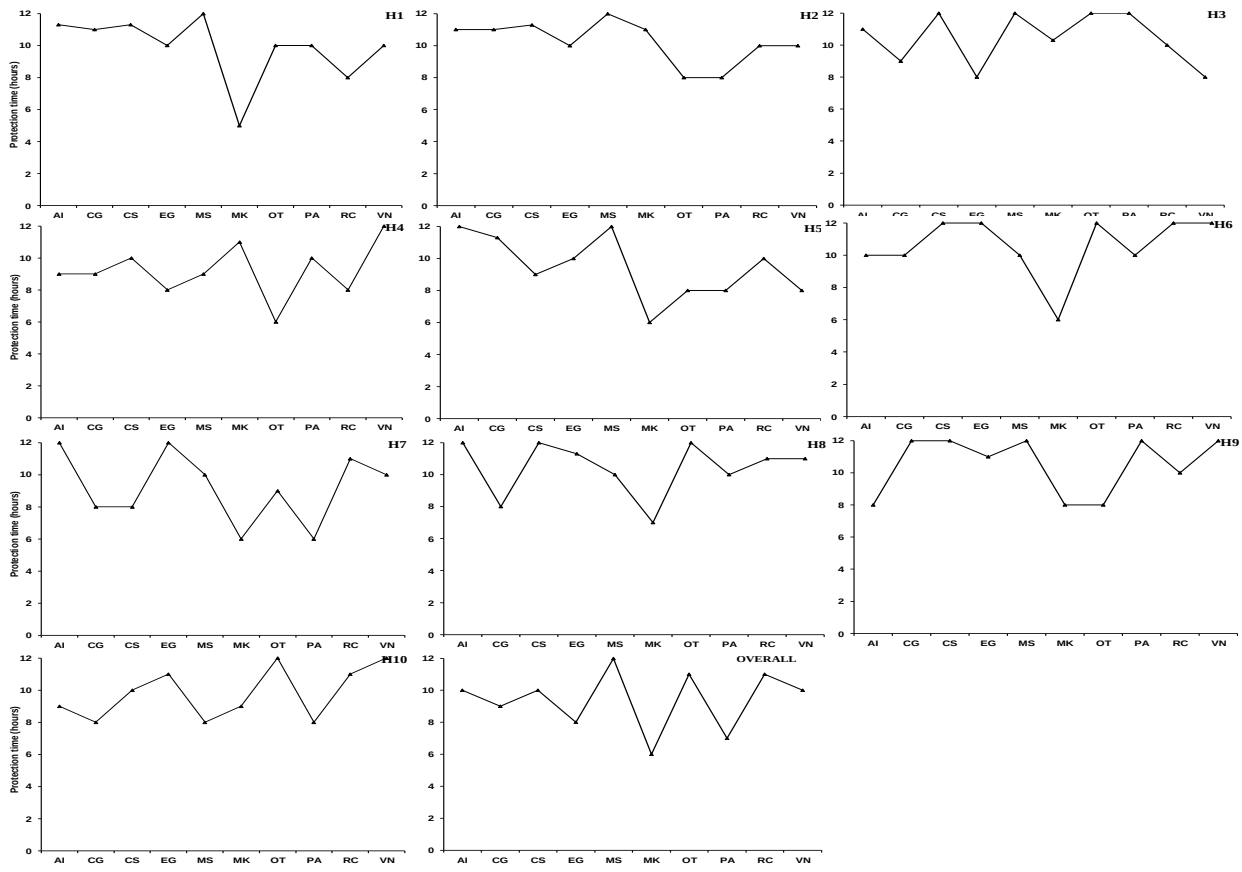

Figure 1. Protection time delivered by plants against mosquitoes.

The repellent activity of plants might be due to the presence of certain chemicals that are able to irritate the olfactory senses of the mosquitoes. These chemicals can be grouped into alkaloids and flavonoids. Alkaloids are non-volatile and release insecticidal smoke when the plant materials or the mosquito coil containing the active ingredients are burnt. They repel the mosquitoes through direct toxicity (Sears, 1996). Their mode of action varies but many affect acetylcholine receptors in the nervous system or membrane sodium channels of nerves. Flavonoids perform repellent function and are categorized into three groups. Firstly, the flavones which are found in the Lamiaceae, Apiaceae and Asteraceae. The second important group is the isoflavonoids found mainly in the Leguminosae: an example of which is the highly insecticidal compound rotenone present in *Derris eliptica* which is a potent mitochondrial poison (Haley, 1978). The other main group in deterring insects are the tannins which are found throughout the plant kingdom and exhibit toxicity by binding to proteins (Schultz, 1989).

The duration of protection by a repellent may range from 15 minutes to 10 hours and at times the effect lasts much longer. The effectiveness and duration depend on the type of repellent (active ingredients), the mode of application, local conditions (temperature, humidity and wind), the attractiveness of individual people to insects, loss due to removal by perspiration and abrasion (Mehr *et al*., 1985) and the sensitivity of the insect to repellents since each species has its own specific sensitivity. As repellents act in the vapour phase, some active ingredients may be initially very effective at repelling mosquitoes, but, as they evaporate, their effect rapidly declines. Their longevity may be prolonged by incorporating them in oleaginous or semi-solid preparations. There is a clear evidence that plants are widely used, and culturally acceptable throughout the developing world, and many have proven efficacious against mosquitoes (Willcox *et al*., 2004).

Plant products commonly deter haematophagous insects which is an evolutionary coincidence; however, it is very likely that many plant volatiles are deterrent or repellent because they have high vapour toxicity to insects (Willcox *et al*., 2004). In the present investigation, the active ingredients in the smoke which arose out of burning of powdered plant leaves repelled mosquitoes from entering the house. The vapour in the air affects the central nervous system of mosquitoes since they contain toxic principle which plays a vital role in the control of vectors (Sujatha, 1988) and this principle was observed in the present study. First, the smoke may disguise human kairomones and disrupts convention currents essential in mosquito host location. Secondly, burning plants, release repellent irritant molecules (Charlwood & Jolley, 1984). Thirdly, smoke of herbal leaves seems to be an effective mosquito repellent and this has distinct advantages over chemical repellent because it does not leave poisonous residues and also does not pollute the environment. However, the action of natural smoke is poorly understood. It is likely that smoke may mask human kairomones, particularly carbon dioxide. In addition, mosquitoes rely on heat and moisture in connection currents as a short-range cue for approach to hosts (Takken, 1991) and these too may be altered by combustion. Smoke production also lowers humidity by reducing the moisture carrying capacity of the air. This makes mosquitoes susceptible to desiccation and reduces sensory input because mosquito chemoreceptors are more responsive in the presence of moisture (Davis & Bowen, 1994) and indeed, heat alone is repellent to mosquitoes. Keeping in the view of above mentioned factors it is indicated that chemicals released from burning plants play an important role in repelling host-seeking mosquitoes.

The mode of action of repellent is in fact largely unknown. Repellents disturb the capacity of receptors in mosquito antennae to respond to the post stimuli (Davis, 1985). The spatial repellency is considered to occur through two main modes of pyrethroid action; knock down activity or binding or disruption of orientation towards the host. The latter may be categorized as a sub lethal effect that results from neutral excitement which appears to occur at the earlier stage of toxication or at the dosage required to knock down (Birley *et al*., 1987). MacIver (1964) defined the repellency "associated with pyrethroids as the reaction of mosquito at threshold level at neural activation and knock down occur resulting in the loss of power to orient towards the host". Kawada *et al*. (2009) reported that female mosquitoes exposed for a few minutes to the smoke of a pyrethroid based mosquito repellent did not bite.

CONCLUSION

Therefore, the use of plants is an alternative not only for repelling mosquitoes but for also minimizing the noxious effects of some pesticidal compounds on the environment (Fradin & Day, 2002). It may be concluded that natural products from plants of insecticidal and medicinal values have higher efficiency in reducing mosquito menace due to their repellent toxicity. Further studies on the in-depth field bioassays are needed as the present study shows that there is scope to use local plants to repel mosquitoes.

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