Screening of Local Plants for Their Repellent Activity against Mosquitoes (Diptera: Culicidae)

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Abstract A preliminary screening was carried out on five plants viz., Azadirachta indica, Citrus medica, Murraya koenigii, Ocimum tenuiflorum and Ricinus communis for their repellent activity against mosquitoes. The repellent activity was studied under natural conditions in the field making use of the traditional knowledge as background. Field observations were undertaken in houses wherein dried powdered plant leaves each (250 g) burnt on glowing charcoal produced smoke act as a repellent mosquitocide. Results indicated that among the five plants utilized, Azadirachta indica, Murraya koenigii and Citrus medica provided repellence with a protection time of six hours followed by Ricinus communis and Ocimum tenuiflorum with four 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 laboratory and field bioassays are needed as the present study indicated the scope to use local plants to control and repel mosquitoes.

Keywords Mosquitoes; Plants; Repellent activity

Introduction

Prevention of man mosquito contact is indispensable for protection from mosquito-borne diseases and uses of repellents have been advocated for the same. Insect repellents date back to ancient times, with the use of tars, smokes, plant oils and other modalities (Peterson and Coats, 2001). In recent years, new synthetic repellents have been formulated and advocated. However, continuous and indiscriminate use of these synthetic repellents causes adverse effects on the user (Mandal, 2011). There has been a paradigm shift towards botanicals to overcome the problems associated with the use of synthetic compounds. Plant products have been used traditionally to repel and kill mosquitoes in many parts of the world. Thousands of plants have been tested as potential sources of insect repellents (King, 1954; Jacobson, 1990; Sukumar et al., 1991). Plant based products have been used as repellents either as topical applicant (Samuel et al., 2012a) or fumigant and many plant species have been screened for their repellent and insecticidal property against mosquitoes (Sukumar et al., 1991; Shalan et al., 2005; Sakthividivel and Daniel, 2008; Govindarajan and Sivakumar, 2011; Kamaraj et al., 2011; Samuel et al., 2011, 2012a,b,c,d; Ghosh et al., 2012; Ravindran et al., 2012).

Repellent properties are reported in plants viz., Eucalyptus maculate citriodion against Anopheles gambiae and Anopheles funestus (Trigg, 1996), Pelargonium reniforme against Anopheles arabiensis (Govere et al., 2000), Curuma longa, Cymbopogon winterianus and Ocimum americanum against Aedes aegypti, Anopheles dirus and Culex quinquefasciatus (Tawatsin et al., 2001), Mentha piperita against Anopheles annularis, Anopheles culicifacies and Culex quinquefasciatus (Ansari et al., 2000), Litsea cubeba, Melaleuca leucadendron, Melaleuca quinquenervia, Viola odorata and Nepeta cataria against Aedes aegypti, Anopheles stephensi and Culex quinquefasciatus (Amer and Mehlhorn, 2006). Cymbopogon winterianus and Tagetes minuta showed good repellency effect against Anopheles stephensi, Aedes aegypti and Culex quinquefasciatus (Tyagi et al., 2005).
Interest in anti-mosquito products of plant origin is being revived because of the drawbacks associated with the continued application of synthetic compounds, some of which have led to widespread development of insecticide resistance. Some people mainly in rural areas burn plant materials using glowing charcoal to produce smoke which repels or kills mosquitoes. Therefore, in the present study, evaluations were carried out by burning leaves of five plants viz., Azadirachta indica, Citrus medica, Murraya koenigii, Ocimum tenuifloreum and Ricinus communis using glowing charcoal for their repellent activity against mosquitoes.

1 Results
In the present study, the repellent activity of selected local plants viz., Azadirachta indica, Citrus medica, Murraya koenigii, Ocimum tenuifloreum and Ricinus communis was evaluated. The results indicated that amongst the five plants utilized, Azadirachta indica, Murraya koenigii, Citrus medica exhibited more repellence followed by Ricinus communis and Ocimum tenuifloreum with a range between 25 to 75% repellent activity (Table 1). Maximum repellence was provided by Azadirachta indica leaves in house 1 with a protection time of six hours. In house 2 it was Azadirachta indica and Murraya koenigii and in house 3, Murraya koenigii and Citrus medica with six hours, whereas in house 4 it was Azadirachta indica, Ricinus communis and Ocimum tenuifloreum with four hours (Figure 1). House 5 which served as negative control provided forty five minutes protection time and in the case of house six (positive control) no repellence was observed. The present study also indicated that the incidence of mosquito bites significantly reduced after usage of plant products.

2 Discussion
Mosquitoes are a serious threat to public health transmitting several dangerous diseases for over two billion people in the tropics. There has been a large increase in the insecticide resistance of this vector and has become a global problem. Insecticides residues in the environment, as a result of chemical insecticide usage, have turned the researcher’s attention towards natural products (Murty and Jamil, 1987). In the past years, the plant kingdom has been of great interest as a potential source of insecticidal products. Many species in the plant kingdom synthesize a variety of secondary metabolites which play a vital role in defense of plants against insects/mosquitoes. Plants may be alternative source for mosquito repellent agents since they constitute a rich source of bioactive chemicals (Wink, 1993). Plant products can be used, either as an insecticide for killing larvae or adult mosquitoes or as repellents for protection against mosquito bites, depending on the type of activity they posses (ICMR, 2003). Products of secondary plant metabolisms may be responsible for the chemical communication between plants and insects. Allelochemicals have been considered as potential natural insecticides and can be used for insect/mosquito management in integrated control (Jilani and Su, 1983). Phytochemicals obtained from plants are usually less environmentally harmful than synthetic chemicals and it has renewed the interest in the research on phytocompounds, 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 identification of novel effective mosquitocidal compounds from botanicals containing active phytochemicals.

<table>
<thead>
<tr>
<th>Plant name</th>
<th>Scientific name</th>
<th>Vernacular name (Tamil)</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neem</td>
<td>Azadirachta indica</td>
<td>Vembu</td>
<td>Meliaceae</td>
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<tr>
<td>Lemon</td>
<td>Citrus medica</td>
<td>Naarthangaai</td>
<td>Rutaceae</td>
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<tr>
<td>Curry leaf</td>
<td>Murraya koenigii</td>
<td>Karuveppilai</td>
<td>Rutaceae</td>
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<td>Holy basil</td>
<td>Ocimum tenuifloreum</td>
<td>Ram/Lakshmi tulsi</td>
<td>Lamiaceae</td>
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<tr>
<td>Castor</td>
<td>Ricinus communis</td>
<td>Amanakku</td>
<td>Euphorbiaceae</td>
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Phytochemicals obtained from plants with proven mosquito control potential can be used as an alternative to synthetic potential insecticides or along with other insecticides under the integrated vector control.

Repellents have an important place in protecting man from the bites of insect pests. An effective repellent will be useful in reducing man vector contact and in the interruption of disease transmission. Mosquito repellents may be one of the most effective tools for protecting human from vector-borne diseases and nuisance caused by mosquitoes (Curtis et al., 1990; Barnard, 2000). Repellent compounds should be non-toxic, non irritating and long lasting (Kalyanasundaram and Babu, 1982). Repellents are substances that act locally or at a distance, deterring an arthropod (insect/mosquito) from flying to, landing on or biting human or animal skin (Blackwell et al., 2003; Choochote et al., 2007). Usually, insect repellents work by providing a vapour barrier deterring the arthropod (insect/mosquito) from coming into contact with the surface (Brown and Hebert, 1997) and sometimes, applied on to the skin for protection. Repellents of plant origin do not pose hazards of toxicity to humans and domestic animals and are easily biodegradable. Natural products are safe for humans when compared to that of synthetic compounds (Sharma et al., 1993; Ansari and Razdan, 1996). Repellents are used as personal protection methods against biting arthropods with a major aim of avoiding nuisance (Trigg and Hill, 1996). Repellents properly utilized are an inexpensive means of reducing or preventing arthropod-borne diseases and biting nuisance while acting as a wide range of vectors (Gupta and Rutledge, 1994).

Smoke is still, the most widely used common method of repelling biting insects that is used throughout the world. Fresh and dried plants are frequently added to fires to enhance the repellent properties of the smoke (Roemantyo, 1990). Several field evaluations, where plants were burned to repel mosquitoes, have shown good reduction in mosquito landings (Palsson and Jaenson, 1999a,b). Most households in the developing world rely on personal protection measures of limited effectiveness, such as burning mosquito coils or leaves (Hanson et al., 2003). Mosquito coils were traditionally made with finely ground *Chrysanthemum cinerariaefolium* flowers mixed with coconut husks or sawdust (Chadwick, 1985) and also neem kernels and leaves are burned to repel mosquitoes along with mosquito coils (Konradsen et al., 1997). Plants of terrestrial origin have also been reported to be a source of mosquito repellents (Hwang et al., 1985;
Pandian et al. (1989) observed the repellent activity of herbal smoke on the biting activity of *Culex quinquefasciatus*. Thangam and Kathiresan (1992) stated that smoke from burning various dry materials has been used since early times to deter insects especially mosquitoes. Hwang et al. (1985) observed that the bundles of dried *Artemisia vulgaris* were burned to repel biting insects since it contains insect repellents that can be released from the plant by combustion. The smoke of the leaves of *Vitex negundo* and *Leucas aspera* were found more toxic to the filarial vector mosquito, *Culex quinquefasciatus* than the synthetic mosquito mats which contain 4% d-allethrin. *Anopheles karwari* was repelled by coconut husks, ginger and betel nut leaves. Culicines were repelled by mango wood, coconut husks, ginger and betel nut leaves (Vernede and Marnix, 1994).

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 three major categories viz., alkaloids, phenolics and terpenoids. Alkaloids are basically insecticidal at low concentration, nevertheless they can be used as a repellence. They 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). Mosquito repellent chemicals present in the plant contain phytochemicals like, methone, limonene, beta pinene, alpha pinene and linaliol (Eun, 2001). Burning wood and adding repellent plants to it probably works in several ways. First, the smoke may disguise human kairomones and disrupts convention currents essential in mosquito host location. Secondly, burning may, release repellent irritant molecules and the molecules released by the plants also may be insecticidal (Charlwood and Jolley, 1984). Therefore, the use of plants in mosquito control is an alternative pest control method for minimizing the noxious effects of some pesticidal compounds on the environment (Fatope et al., 1993). Botanicals have widespread insecticidal properties and will obviously work as a new weapon, and in future may act as suitable alternative product to fight against vector mosquitoes (Ghosh, 2012). It may conclude that natural products from plants of insecticidal and medicinal values have higher efficiency in reducing mosquito menace due to their repellent toxicity. Further in-depth laboratory studies and field bioassays are needed as the present study indicated that there is scope to use local plants to control and repel mosquitoes.

### 3 Material and Methods

#### 3.1 Collection of plants

Five plants viz., *Azadirachta indica, Citrus medica, Murraya koenigii, Ocimum tenuifloreum* and *Ricinus communis* were collected in and around Tambaram, Chennai, Tamil Nadu, India. The plants were selected based on available literature, abundant availability, medicinal and insecticidal properties. The details of collected plants utilized for the present study are presented in Table 2. The collected plant leaves were brought to the laboratory, washed with dechlorinated water, shade dried under room temperature and was then powdered individually.

#### 3.2 Bioassay

Powdered plant parts burned on glowing charcoal produce smoke acts as a repellent mosquitoide (Kazembe and Nkomo, 2010). In the present study, the same methodology was adopted. The repellent activity was studied under natural conditions in the field. Field observations were undertaken in Meenakshi Avenue, Old Perungalathur, Chennai, Tamil Nadu, India based on the assessment of mosquito density status in the natural/domestic habitats during dusk which involved direct observations. A total of six houses were selected of which four were used for treatment. The house treated with burning of charcoal only served as negative control and the other house as positive control did not receive any treatment including charcoal. In each of the four houses selected for treatment, the dried powdered leaves of each plant (250g) were burnt on glowing charcoal. The burning of five plant leaves was changed in a cyclic manner to avoid bias during each trial. A total of five trials were carried out. The experimental set up was kept out of reach of children and use of mosquito repellents was discouraged during the period of study. Prior to the start
Table 2 Repellent activity of plants against mosquitoes

<table>
<thead>
<tr>
<th>Plant leaves</th>
<th>Azadirachta indica</th>
<th>Citrus medica</th>
<th>Murraya koenigii</th>
<th>Ocimum tenuiflorum</th>
<th>Ricinus communis</th>
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</table>

Note: +++: 75% activity; ++: 50% activity; +: 25% activity

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.

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