Original Article

Chemical Composition, Larvicidal and Repellency Properties of *Cionura erecta* (L.) Griseb. Against Malaria Vector, *Anopheles stephensi* Liston (Diptera: Culicidae)

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Abstract

**Background:** Application of plant derivatives have been suggested as alternative sources for mosquito control.

**Methods:** The root essential oil and methanol extract of *Cionura erecta* (L.) Griseb was tested under laboratory conditions for larvicidal and skin repellency activities against *Anopheles stephensi*. The chemical compositions of essential oils were analyzed using gas chromatography-mass spectrometry.

**Results:** Among the five concentrations tested, the 320 ppm of essential oil and 1280 ppm of methanolic extract had the most toxic effects yielding 100% mortality. The LC50 values of *C. erecta* for both essential oil and methanolic extract were 77.30 and 250.38 ppm, respectively. A total of 19 compounds were identified in root essential oil. The major components were detected in root essential oil including Cedren-9-one (7.89%), alpha cadinol (5.67%), eugeno (4.02%) and alpha muurolene (3.58%). The protection time of 50% solution of essential oil against bites of *An. stephensi* was 2.28 hour on white rabbit and the ED50 and ED90 values of the essential oil were 10.12 and 23.01 ppm respectively.

**Conclusion:** The findings suggest that *C. erecta* oil has a potential source as larvicidal and repellency properties against *An.stephensi*.

**Keywords:** *Cionura erecta*, Extract, Essential Oil, *Anopheles stephensi*, Larvicidal Effect, Repellency

Introduction

The mosquitoes are the important vectors of human diseases and can be transmitted malaria, dengue fever, yellow fever and filariasis. They also bother the people both inside and outside places (Lehane 1991). Malaria is one of arthropod-borne disease and approximately 83000 deaths are reported annually in the world (WHO 2012). At the present, this parasitic disease is one of the main health problems in Iran.

Several chemical compounds have been used against malaria vectors as larvicides including organophosphates, insect growth regulator and microbial derved compounds (Ghosh et al. 2012). Use of synthetic insecticides is causing various problems such as environmental pollution, insecticide resistance and toxic hazards to humans and animals (Aktar et al. 2009, Kunz and Kemp 1994, Vatandoost et al. 2005).

Therefore using plant derivatives have been suggested as alternative sources for mosquito control. They are selective, safe and biodegrade to break down readily in soil and are not stored in plant or animal tissue (Isman 2000, 2006). The various extracts of local plants have been investigated against *An.
This study was aimed at assessing the potential of plant essential oil and methanolic extract for possible use as larvicidal or repellency activites against *An. stephensi* under laboratory conditions and to determine the chemical composition of the essential oil.

Materials and Methods

Mosquito rearing

The tested mosquitoes were the colony of *An. stephensi* which obtained from the Insectary of School of Public Health, Tehran University of Medical Sciences, Iran, and maintained at 29±1 °C with a photoperiod of 12 hours light and 12 hours dark in 60±10% relative humidity. The enriched wheat germ was used as food source. Larvae of *An. stephensi* were continuously available for the larvicidal and repellency experiments. Starved 7 to 10 days old females were used for the repellency tests and the early fourth-instar larvae used for the larval bioassays.

Plant materials

The fresh branch and root of *C. erecta* collected in August 2011 from rural areas located in western part of Ilam Province, Iran (33° 46' N, 46° 11’ E at elevation 1195m) (Fig. 1). The specimens was identified and authenticated by the Department of Pharmacognosy, Faculty of Pharmacy, Tehran University of Medical Sciences.

Essential oil isolation

Fresh roots (500g) of *C. erecta* were subjected to hydrodistillation using a modified Clevenger-type (Pyrexfan®) apparatus for 3 hour, the oil obtained was separated from water and dried over anhydrous Na2SO4 and transferred into airtight vials at 5 °C.

Analysis of essential oils

Chemical composition of *C. erecta* was analyzed using an Agilent 7890–5975 gas chromatography-mass spectrometer. With a HP-5MS (5% Phenyl Methyl Silox) capillary column (30m×0.25mm, film thickness 0.25 m), split ratio, 1: 1, and using a flame ionization detector. The GC was programmed at 50 °C for 2min and then increased at 5 °C/min to 280 °C, and finally held with an isothermal for 3min. The injector temperature was 280 °C. The flow rate of the carrier gas was 1ml/min. The identification of compounds was performed by comparing their retention times and mass spectra with mass spectra from Wiley library. Additional identification was achieved by comparing linear retention indices, relative to n-alkanes, to those from literature (Adams
Details on the identification of volatile compounds were reported in previous paper (Myrianthopoulos et al. 2007).

**Methanolic extract of plant**

The branch and root of *C. erecta* were air-dried at room temperature and 100g of plant were submitted to percolation separately with methanol (80%) during 3 days, and this procedure were repeated for three times successive and totally last nine day at laboratory temperature (22 to 25 °C). The extracts were next evaporated in a rotary evaporator (Heidolph Persia®).

**Larvicidal tests**

The essential oil and methanol extract first dissolved in absolute ethanol (99.0%) and methanol (99.0%) respectively. The 400ml glass beakers were used for the treatment or untreated experiments. The third or early fourth instar larvae were exposed to 10, 20, 40, 80 and 160ppm and 40, 80, 160, 320, 640, 1280 ppm of both essential oil and methanolic extract respectively according to standard WHO procedure (WHO 1981).

**Repellency tests**

The white rabbits (*Oryctolagus cuniculus*) (laboratory reared albino male aged six months) were used to determine both protection time and effective dosage. The 25, 50 percent and pure essential oil of *C. erecta* was prepared using absolute ethanol as well as this solvent used for untreated group against *An. stephensi* on the shaved back of male rabbits with 4 repititions. The procedure for determination of effective dosages of the repellents was adopted by the standard method of American Society for Testing and Material (ASTM 2000). The testing kit was made of plexiglas cube at dimension of 4x5x18cm having four rectangular holes 2 ×3cm. Before starting the test for determination of effective dosage, the abdomen skins of rabbits were cleaned with alcohol and the kit was fixed on the abdomen. The eligibility of the rabbits for repellency tests was 10 landings or probes within 30 seconds. Each of 4 adjacent cells of kit was provided with 5 female 7–10 days mosquitoes that randomly selected from a cage containing 150 starved mosquitoes. Five circles were drawn on the rabbit's skin. The drawn circles on the abdomen skin’s of holded rabbit were treated with 25µl of essential oil diluted with absolute alcohol at 2, 4, 8, 16, 32ppm with 4 repititions. The serial dilutions were applied on 3 holes as well as the absolute ethanol was applied in remaining control circle. The treated circles were allowed to dry, and then test apparatus containing starved mosquitoes were fixed on the treated skin. The counts of probing and biting were recorded at 1 minute intervals up to 5 minutes. After each test, the mosquitoes were transferred to netted cups and the mortality of mosquitoes was recorded after 24 hours. The ED<sub>50</sub> and ED<sub>90</sub> values and regression parameters were analyzed using probit 79 program and the regression lines were plotted in Microsoft Excel 2007.

**Ethical approval**

Animal experiments were performed after obtaining Institutional Animal Ethical Committee’s approval from Tehran University of Medical Sciences.

**Results**

**GC-mass analysis**

The hydrodistillation of the *C. erecta* root gave oil in 0.16% (w/w) yield on fresh weight material. A total of 19 compounds was 36.4% in roots of *C. erecta* were identified (Table 1). The major components in root oil were cedren-9-one (7.89%), alpha cadinol (5.67%), eugenol (4.02%) and alpha muurolene (3.58%) respectively.

**Mosquito larvicidal activity**

The larvicidal activities of both essential
oil and methanol extract of the C. erecta root against An. stephensi larvae under laboratory conditions are shown in Table 2. Among the five concentrations tested, the dosages of 320 ppm and 1280ppm of essential oil and methanolic extract were respectively found to be the most toxic with 100% larval mortality. The essential oil C. erecta extracted with root and showed the higher toxicity than methanolic extract against the larvae. The LC50 and LC90 values of C. erecta essential oil were 77.30 and 199.58ppm, and for methanolic extract were recorded 250.38 and 490.00ppm, respectively.

**Effective doses**

The ED50 and ED90 values of C. erecta essential oil were 10.12 and 23.01ppm with confidence intervals ranged, 7.89–13.9 and 16.12–50.37 respectively (Table 4).

**Protection time**

The 25%, 50% and pure essential oil C. erecta against An. stephensi on animal subject were provided 2.0–3.15 hours protection. The repellent failure time was ranged 2.5–4.25 hours (Table 3).

**Effective doses**

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<table>
<thead>
<tr>
<th>No.</th>
<th>Compounds</th>
<th>Composition%</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,4 decadienal</td>
<td>1.3</td>
<td>1307</td>
</tr>
<tr>
<td>2</td>
<td>dimethyl phenyl acetate</td>
<td>1.25</td>
<td>1315</td>
</tr>
<tr>
<td>3</td>
<td>Eugenol</td>
<td>4.02</td>
<td>1360</td>
</tr>
<tr>
<td>4</td>
<td>beta elemen</td>
<td>0.332</td>
<td>1391</td>
</tr>
<tr>
<td>5</td>
<td>alpha humulene</td>
<td>0.21</td>
<td>1457</td>
</tr>
<tr>
<td>6</td>
<td>Trans caryophyllene</td>
<td>0.71</td>
<td>1473</td>
</tr>
<tr>
<td>7</td>
<td>alpha muurolene</td>
<td>3.58</td>
<td>1483</td>
</tr>
<tr>
<td>8</td>
<td>delta cadinene</td>
<td>1.52</td>
<td>1404</td>
</tr>
<tr>
<td>9</td>
<td>caryophyllene oxide</td>
<td>1.38</td>
<td>1540</td>
</tr>
<tr>
<td>10</td>
<td>Viridiflorol</td>
<td>0.55</td>
<td>1546</td>
</tr>
<tr>
<td>11</td>
<td>Silphiperfolenone</td>
<td>0.85</td>
<td>1551</td>
</tr>
<tr>
<td>12</td>
<td>Trans cadinene</td>
<td>0.64</td>
<td>1569</td>
</tr>
<tr>
<td>13</td>
<td>alpha cadinol</td>
<td>5.67</td>
<td>1577</td>
</tr>
<tr>
<td>14</td>
<td>Eudesmol</td>
<td>1.78</td>
<td>1584</td>
</tr>
<tr>
<td>15</td>
<td>gama epoxy elemen</td>
<td>0.69</td>
<td>1598</td>
</tr>
<tr>
<td>16</td>
<td>Cedren-9-one</td>
<td>7.89</td>
<td>1633</td>
</tr>
<tr>
<td>17</td>
<td>Isolongifolene-5-one</td>
<td>2.15</td>
<td>1644</td>
</tr>
<tr>
<td>18</td>
<td>Tetradecanol</td>
<td>1.34</td>
<td>1648</td>
</tr>
<tr>
<td>19</td>
<td>Cadalene</td>
<td>0.58</td>
<td>1677</td>
</tr>
</tbody>
</table>

*RI: Retention indices determined on HP-5 column*
Fig. 1. The plant C. erecta in its natural habitat, Ilam Province, west of Iran (original)

Table 2. LC50 and LC90 values of essential oil and methanolic extract of Cionura erecta roots against larvae of An. stephensi

<table>
<thead>
<tr>
<th>Type of extraction</th>
<th>a</th>
<th>b ± SE</th>
<th>LC50 (ppm) ± 95% C.L.</th>
<th>LC90 (ppm) ± 95% C.L.</th>
<th>$\chi^2$ (heterogeneity)</th>
<th>$\chi^2$ table (df)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential oil</td>
<td>-5.87</td>
<td>10.11 ± 0.34</td>
<td>69.28</td>
<td>169.71</td>
<td>5.419 *</td>
<td>11.345 (3)</td>
<td>0.01</td>
</tr>
<tr>
<td>Methanol extract</td>
<td>4.40</td>
<td>10.54 ± 0.34</td>
<td>229.078</td>
<td>434.03</td>
<td>11.999 *</td>
<td>13.277 (4)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* No heterogeneity

Table 3. Protection and failure times of essential oil of Cionura erecta against Anopheles stephensi on abdomen of albino rabbits at laboratory condition

<table>
<thead>
<tr>
<th>Concentration of essential oil</th>
<th>Protection time (h) ± SD</th>
<th>Failure time (h) ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>2.01 ± 0.95</td>
<td>2.5 ± 0.5</td>
</tr>
<tr>
<td>50%</td>
<td>2.28 ± 1.6</td>
<td>3.25 ± 1.7</td>
</tr>
<tr>
<td>100%</td>
<td>3.15 ± 1.7</td>
<td>4.25 ± 1.7</td>
</tr>
</tbody>
</table>

Table 4. Effective doses of essential oils Cionura erecta (L.) roots against An. stephensi on albino rabbits

<table>
<thead>
<tr>
<th>a</th>
<th>b ± SE</th>
<th>ED50 (mg/cm²) ± 95% C.L.</th>
<th>ED90 (mg/cm²) ± 95% C.L.</th>
<th>$\chi^2$ (heterogeneity)</th>
<th>$\chi^2$ table (df)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.59</td>
<td>3.575 ± 0.784</td>
<td>7.89</td>
<td>16.12</td>
<td>3.048*</td>
<td>13.277 (3)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* No heterogeneity

Discussion

Application of larvicides and repellents are generally accepted as the playing a significant role in control of the mosquitoes.

In this study, major constituents of root essential oil of C. erecta were evaluated. Cedren-9-one (7.89%), alpha cadinol (5.67 %), eugenol (4.02%) and alpha muurolene (3.58%) were found as main compounds. The chemical ingredients of C. erecta essential oil was reported comprised 72 compositions.
ponents, from which the main one considered as safranal (16.8%), (Z)-3-hexenyl benzoate (6.1%), heneicosane (5.7%) linalool (4.8%) and tricosane (4.4%) (Myrianthopoulos et al. 2007). Some constitute was not found in our study.

According to the larvicidal assay, the essential oil and methanol extract of C. erecta were effective against An. stephensi with LC50 and LC90 values of 77.30ppm and 250.38 ppm, respectively. The bioassay of different herbal extracts has been studied against An. stephensi larvae in Iran. There is a report about the efficacy of the essential oil and methanolic extract of Eucalyptus camaldulensis against An. stephensi in which, the LC50 and LC90 values were found 89.85ppm and 397.75 ppm, respectively (Sedaghat et al. 2010). The larvicidal activity of Azadirachta indica extract against An. stephensi were gained 0.35 ppm and 1.81ppm respectively for LC50 and LC90 values (Vatandoost and Vaziri 2004). Also the LC50 and LC90 of Cupressus arizonica essential oil have been reported respectively 79.30ppm and 238.89 ppm against An. stephensi (Sedaghat et al. 2011b). The larvicidal activity of three plants from the family Apiaceae have been studied and the LC50 values of three essential oils ranged from 20.10 to 120.95ppm (Sedaghat et al. 2011a). In the other study, the efficacy of Kelussia odoratissima essential oil was evaluated at dose of 10ppm induced 100% larval mortality, against larvae of both An. stephensi and Cx. pipiens (Vatandoost et al. 2012).

The repellency effect of the C. erecta essential oil against An. stephensi was first evaluated under laboratory conditions. The mean protection time of 50% essential oil of C. erecta provided 2.15 hours protection against An. stephensi. The figures for for ED50 and ED90 values were 10.12 and 23.01ppm respectively. The repellency effect of essential oils of many plants has been evaluated against An. stephensi (Ansari et al. 2000, Prajapati et al. 2005, Klun et al. 2006, Rajkumar and Jebanesan 2007, Mullai et al. 2008, Pandey et al. 2009, Govindarajan et al. 2011, Prabhu et al. 2011).

The repellency effect of essential oils of both Myrtus communis and Calendula officinalis had been reported and the ED50 values were 0.11 and 0.6 mg/cm², respectively on human subjects (Tavassoli et al. 2011). Other laboratory trial revealed the repellency of 3 chemical and herbal repellents against An. stephensi. The ED50 value of neem tree’s essential oil was 0.191 mg/cm² against field strain of mosquitoes (Vatandoost et al. 2008).

The results indicated both the repellency of essential oil as well as the larvicidal activity of C. erecta extract against An. stephensi.

Conclusion

Results of this study will provide a clue for possible use of plants for control of mosquito-borne disease.

Acknowledgments

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References

tracts and essential oil of Citrus limon (Rutaceae) and Melissa officinalis (Labiatae) against main malaria vector, Anopheles stephensi (Diptera: Culicidae) in Iran. Iran J Public Health. 32: 47–52.


Sedaghat MM, Sanei-Dehkordi A, Khanavi M, Abai MR, Mohtarami F, Vatan-

WHO (1981) Instruction for determining the susceptibility or resistance of mosquito larvae to insecticides. World Health Organization-VBC.
