Larvicidal and Oviposition Deterrent Activities of Essential Oils against House Fly (*Musca domestica* L.; Diptera: Muscidae)

Soonwera, M.*

Plant Production Technology Section, Faculty of Agricultural Technology, King Mongkut’s Institute of Technology Ladkrabang, Bangkok 10520, Thailand.


**Abstract** House fly (*Musca domestica* L.) is one of the most important insect pests of household and livestock, their has been developed resistance to chemical insecticides. In fact, green pesticides derived from plant essential oils are an excellent alternative to synthetic pesticides. In the present study, the Thai essential oils derived from ylang-ylang (*Cananga odorata* Lamk), citronella grass (*Cymbopogon nardus* (L.) Rendle) and clove (*Syzygium aromaticum* L.) were evaluated for their larvicidal and oviposition deterrent activity against house fly and compared them with chemical insecticide (cypermethrin 10.0% w/w, kumakai 10®). The highest larvicidal activity and oviposition deterrent activity was shown by *S. aromaticum* oil with LC₅₀ values of 9.83% and 100% effective repellency and -1.0 OAI at 1.65µl/cm². Moreover, *S. aromaticum* oil also exhibited the higher larvicidal and oviposition deterrent activity than cypermethrin. However, toxicity assay indicates the order of LC₅₀ values and percentage of effective repellency against house fly in three essential oils as *S. aromaticum* oil > *C. odorata* oil > *C. nardus* oil. These results clearly revealed that *S. aromaticum* oil served as green pesticides to control house fly population and safe for human and environmental friendly.

**Keywords**: herbal essential oils, larvicide, oviposition deterrent, *Musca domestica*

**Introduction**

House fly, *Musca domestica* L. (Diptera: Muscidae) is an important medical and veterinary insect pests causing a serious diseases to human and

*Corresponding author*: Soonwera, M.; **Email**: mayura.soon@gmail.com
livestock by vectoring more than 100 human and animal pathogenic organisms such as protozoa cysts, helminth parasites, enteropathogenic bacteria and enterovirus (Tarelli et al., 2009; Hana, 2013). In Thailand, Maipanich et al. (2010) reported the eleven kinds of helminth eggs and larvae were found on house flies in fifty-one tourist areas in twenty-two province of Thailand, including Bangkok, such as Ascaris lumbricoides, Trichuris trichiura, Enterobius vermicularis, Taenia spp., Spirometra sp., Opisthorchis viverrini, Echinostoma sp. and Eurytrema sp. In fact, control of house fly commonly depended on chemical pesticides, because of their speedy action and easy application. Unfortunately, the resistance of house fly to chemical pesticides have increased (Khan et al., 2013). Moreover, chemical pesticides also have toxic side effect to humans, animals and environment (Sinthusiri and Soonwera, 2013). However, the alternative strategies for house fly control are need. Therefore, the environmental friendly and biodegradable natural pesticides from plants origin have been receiving attention as an alternative green pesticide for controlling insect pests (Phasomkusolsil and Soonwera, 2012). The essential oils from plants or herbs are documented for exhibition of acute toxicity, anti-feeding and oviposition deterrents against a wide variety of insect pest, including house fly (Isman, 2006; Koul et al., 2008). Moreover, plant essential oils considered for controlling house fly because of their selectivity, high toxicity for insect, target specificity, minimal environmental effects and safety to humans (Tarelli et al., 2009; Kumar et al., 2013). Besides, many researchers have reported the bioefficacy of essential oils from Cymbopogon citratus, Cymbopogon nardus, Cymbopogon winterianus, Citrus sinensis and Pogostemon cablin were evaluated for their insecticidal activity against larvae, pupae and adults of house fly (Palacios, 2009; Pavea, 2008, Kumar et al., 2011; Kumar et al., 2012; Morey and Khandagle, 2012; Sinthusiri and Soonwera, 2010). Sinthusiri and Soonwera (2013) also reported that the insecticidal effects of twenty essential oils derived from herbs against adult of house fly, the most effective were shown by C. citratus oil, M. piperita oil and L. angustifolia oil, showing 100% mortality at 24 h. and LT_{50} (median lethal time) values of 2.22, 2.62 and 3.26 min., respectively. However, C. odorata oil exhibited high potential of oviposition deterrent and ovicidal action against three mosquito species (Aedes aegypti, Anopheles dirus and Culex quinquefasciatus (Phasomkusolsil and Soonwera, 2012).

Therefore, the aim of this study was to investigate the larvicidal effect and oviposition deterrent activity of three essential oils from Thai herbs.
(Cananga odorata, Cymbopogon nardus and Syzygium aromaticum) against house fly (M. domestica).

Materials and methods

House fly

Adult house flies were collected through sweep net method from markets in Ladkrabang, Bangkok, Thailand and identified by Entomologist of Faculty of Agricultural Technology, King Mongkut’s Institute of Technology Ladkrabang (KMITL), Thailand. The ten of adult house flies (5 males : 5 females) were reared in screen cages (30x30x30 cm), 10% w/v glucose + 10% w/v milk and 300 g. of mackerel fishes as a food source and oviposition site. The one hundred larvae fed on 300 g of mackerel fishes, the 3rd instar larvae and female adult aged 4-5 days old were used for this study.

Plant materials and essential oils

Various parts of three Thai plant species (Cananga odorata (Flower), Cymbopogon citratus (Stem) and Syzygium aromaticum (Flower)) were collected from Nakhonratchasima province, Thailand. All plant was identified by Plant Taxonomist of Plant Production Technology Section, Faculty of Agricultural Technology, KMITL. The various plant parts were extracted for essential oil by water distillation. Each essential oil was prepared as 1%, 5% and 10% solutions in ethyl alcohol and stored at 4°C before testing.

Chemical insecticide

Cypermethrin 10% w/v (Kumakai 10®), a common chemical insecticide for insect pest control in Thailand was purchased from MD Industry Co., Ltd., 22 Phahonyothin Rd., Wongnoi, Pranakhonsri ayutthaya province, Thailand, used as standard.
**Larvicidal bioassays**

The bioassay was evaluated by using dipping method (Sripongpun, 2008). The ten of 3\textsuperscript{rd} instar larvae were dipped into 10 ML of each test solution for 10 sec. and transferred to a filter paper (in plastic box; 7.5x10.0x7.5 cm), containing a diet of 10 g. of mackerel fishes. Larval mortality was recorded at 1.0, 6.0, 12.0 and 24.0 h. The criteria for larval mortality was evaluated by softy touching each on with a small paint brush and if they not responding were considered dead (Sinthusiri and Soonwera, 2010). Each test was performed in five replicates. The data were pooled and analyzed by standard probit analysis to obtain a LT\textsubscript{50} (median lethal time) and LC\textsubscript{50} (median lethal concentration).

**Oviposition deterrent bioassay**

The ten of female adult house flies aged 4-5 days old, were introduced in a screened cage where two oviposition boxes (7.5x10.0x7.5 cm) lined with cotton pad (3x10x0.25 cm) were introduced for oviposition. For two oviposition boxes, the 1\textsuperscript{st} box as tested box was filled with 1 ML of 10\% w/v milk solution and 1 ML of each test solution, while, the 2\textsuperscript{nd} box served as control was filled with only 1 ML of 10\% w/v milk solution. The position of the boxes were switched everyday to avoid the position effects. The eggs laid into each box were collected separately until no further eggs were laid for at least 48h. The egg collected were counted using a stereomicroscope. Five replicates were carried out with each test solution. The percentage of effective repellency for each essential oil was calculated using the following formula (Phasomkusolsil and Soonwera, 2012; Warikoo \textit{et al.}, 2011).

\[
ER\% = \frac{NC - NT}{NC} \times 100
\]

Where

- \( ER \) = effective repellency
- \( NC \) = the total number of eggs in the control solution
- \( NT \) = the total number of eggs in each test solution

The oviposition experiments were expressed as mean number of eggs and oviposition activity index (OAI), which was calculated using the following formula (Phasomkusolsil and Soonwera, 2012)

\[
OAI = \frac{NT + NC}{NT - NC}
\]

\[
NC = \text{the total number of eggs in the control solution}
\]
NT = the total number of eggs in each test solution

The OAI ranges from -1.0 to + 1.0, with 0 indicating neutral response. The positive index values indicate that more eggs were deposited in the test boxes than in the control boxes, and that the test solutions were attractive, on the other side, more eggs in the control boxes than in the test boxes results in negative index values and the test solutions were deterrent.

Results and discussion

The larvicidal effect of three essential oils and cypermethrin against 3rd instar larvae of house fly as shown in Table 1. On the LT50 values and LC50 values, the results revealed that S. aromaticum oil exhibited highest larvicidal effect against house fly larvae with LT50 values of 27.05 h. and LC50 values of 9.83%, followed by C. nardus oil and C. odorata oil with LT50 values of 38.99 and 52.08 h. and LC50 values of 13.60 and 29.36%, respectively. While, cypermethrin showed LT50 values of 31.63 h. and LC50 values of 11.45%, these LT50 values and LC50 values exhibited fewer toxicity than S. aromaticum oil.

For oviposition deterrent experiments, the results as shown in Table 2. The house fly females preferred to lay eggs in control boxes than test boxes. However, all test solution at 1.65 µl/cm² showed fewer oviposition deterrent activity against house fly females than at 3.30 µl/cm². The highest percentage of effective repellency (ER%) was shown by S. aromaticum oil and C. odorata oil with 100% in 1.65µl/cm² and 3.30 µl/cm² and -1.0 OAI (Oviposition Activity Index). For C. nardus oil exhibited 98.92 to 99.25% ER and -0.98 to -0.99 OAI. While, cypermethrin showed 100% ER and -1.0 OAI. Therefore, the results indicated that all herbal essential oil and cypermethrin were excellent oviposition deterrent against house fly females.

Table 1. Larvicidal effect of three essential oils from Thai herbs and chemical insecticide against 3rd instar larvae of Musca domestica.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Lethal Time (LT50) (h.)</th>
<th>Lethal Concentrations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. odorata oil (ylang-ylang)</td>
<td>52.08</td>
<td>29.36</td>
</tr>
<tr>
<td>C. nardus oil (citronella grass)</td>
<td>38.99</td>
<td>13.60</td>
</tr>
<tr>
<td>S. aromaticum oil (clove)</td>
<td>27.05</td>
<td>9.83</td>
</tr>
<tr>
<td>cypermethrin</td>
<td>31.63</td>
<td>11.45</td>
</tr>
</tbody>
</table>
Table 2. Oviposition deterrent effect of three essential oils from Thai herbs and chemical insecticide against *Musca domestica* female.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Concentration (µl/cm²)</th>
<th>Effective Repellency (%)</th>
<th>OAI</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. odorata</em> oil</td>
<td>1.65 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
<tr>
<td>(ylang-ylang)</td>
<td>3.30 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
<tr>
<td><em>C. nardus</em> oil</td>
<td>1.65 µl/cm²</td>
<td>98.92</td>
<td>-0.98</td>
</tr>
<tr>
<td>(citronella grass)</td>
<td>3.30 µl/cm²</td>
<td>99.25</td>
<td>-0.99</td>
</tr>
<tr>
<td><em>S. aromaticum</em> oil</td>
<td>1.65 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
<tr>
<td>(clove)</td>
<td>3.30 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
<tr>
<td>cypermethrin</td>
<td>1.65 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
<tr>
<td></td>
<td>3.30 µl/cm²</td>
<td>100</td>
<td>-1.0</td>
</tr>
</tbody>
</table>
Figure 1. Median lethal time (LC$_{50}$) and percentage of effective repellency (ER%) of three essential oils and cypermethrin against *Musca domestica*.

Our study has revealed that the essential oil from *S. aromaticum* showed the excellent larvicidal and oviposition deterrent activity against larvae and females of house flies and these results exhibited higher toxic than cypermethrin. Moreover, *S. aromaticum* oil also showed the high percentage of effective repellency against oviposition of *Ae. aegypti* and *Cx. quinquefasciatus* with 93.30 and 98.40% and -0.9 and -1.0 OAI, respectively (Phasomkusolsil and Soonwera, 2012). Furthermore, Trongtokit et al. (2005) studied the mosquito repellency of 38 essential oils and found *S. aromaticum* oil to provide the longest and most effective protection time against three mosquito species (*Aedes* sp., *Anopheles* sp. and *Culex* sp.). Shapiro (2012) also reported that eugenol is a natural chemical found in oil of *S. aromaticum* that attracts Japanese beetles, kill insects, and is considered safe without risks when used as directed, and the US Environmental Protection Agency (USEPA) classified *S. aromaticum* oil as minimum risk pesticides. However, *S. aromaticum* oil has been studied for its antibacterial, antimicrobial and antifungal properties against cutaneous infectious manifestations and has been shown to be environmentally safe and nontoxic to humans for use in medicine, perfume and food flavoring. Moreover, *S. aromaticum* oil is commonly used in dental root canal surgery for its antimicrobial properties in Thailand (Trongtokit et al., 2004).
For *C. odorata* oil showed the excellent oviposition deterrent with 100% effective repellency against oviposition of house fly females. Phasomkusolsil and Soonwera (2012) supported these results that, *C. odorata* oil also exhibited high potential for oviposition deterrent and ovicidal action against three mosquito species (*Ae. aegypti*, *An. dirus* and *Cx. quinquefasciatus*). In addition, essential oils from *C. odorata* and *Lippia alba* showed the most active repellent properties against *Tribolium castaneum* (Coleoptera) (Gallardo *et al*., 2011). However, many researcher reported the chemical properties and therapeutic properties of *C. odorata* oil such as Burdock and Carabin (2008) reported the essential oil extracted from flower of *C. odorata* by water distillation showed physical and chemical properties and the constituents of this oil were phenols, eugenol, methyleugenol, isoeugenol, limonene, geraniol and cinnamaldehyde. These constituents have properties to act as toxins, feeding deterrents and oviposition deterrents to a wide variety of insect pests (Koul *et al*., 2008). Moreover, *C. odorata* oil showed therapeutic properties, such as antidepressant, antiseborrhoeic, antiseptic, aphrodisiac, hypotensive, nervine and sedative (Phasomkusolsil and Soonwera, 2012).

However, *C. nardus* oil showed the moderate of larvicidal activity against house fly larvae, but this oil showed high oviposition deterrent activity against house fly females. Our results, supported by Sinthusiri and Soonwera (2010) reported that oil of *C. nardus* showed high insecticidal activity against 2nd instar larvae, pupae and adults of house flies with 100% mortality at 20.0 min., 3 days and 120 sec., respectively. Besides, *C. nardus* oil or citronella oil is approved for use on human as an insect repellent with little or no known toxicity (EPA, 2009).

In the present study it was found that three essential oils from Thai herbs showed high potential as larvicide and oviposition deterrent for house fly control. All essential oil in this study has high potential for development of new product or green product to house fly management. Finally, the green products base on herbal essential oils is considered environmentally safe and offer safer human health alternatives to insect pest control with chemical insecticides, and could be a good option for Thai people.
Conclusion

Thai essential oils from *S. aromaticum*, *C. odorata* and *C. nardus* exhibited high potential for development of green pesticides for house fly control.

Acknowledgments

The authors are highly grateful to Faculty of Agricultural Technology, King Mongkut’s Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand for providing financial assistance to carry out this study. The authors extend thanks to plant taxonomist and entomologist from faculty of Agricultural Technology, KMITL for species identification of herbs and insect.

References


(Received: 27 December 2014, accepted: 14 February 2015)