The insecticidal activity of four medicinal plants against the blowfly *Lucilia sericata* (Diptera: Calliphoridae)

Hanem Fathy Khater, PhD, and D. F. Khater, PhD

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**Abstract**

**Background** The larvae of *Lucilia sericata* induce myiasis and transmit mycobacterial infections to humans and animals. Consequently, the blowfly should be controlled for human welfare and economic reasons.

**Methods** The insecticidal effect of fenugreek (*Trigonella foenum-graecum*), celery (*Apium graveolens*), radish (*Raphanus sativus*), and mustard (*Brassica compestris*) against the third larval instars of *L. sericata* was evaluated, for the first time, through ingestion assays. The effect of sublethal concentrations on certain biological aspects, such as the pupation rates and adult emergence, was revealed.

**Results** The LC<sub>50</sub> values were 2.81, 4.60, 6.93, and 7.92% for fenugreek, celery, radish, and mustard, respectively. The adverse effects on larval treatment also included the survival of pupae and adults. The pupation rate was strongly decreased after treatment with 16% fenugreek and celery. Moreover, adult emergence was suppressed after treatment of larvae with 8% mustard, 12% radish, and 16% fenugreek and celery oils. The number of emerged males exceeded the number of females, which could lead to population decline. Morphologic abnormalities of larvae, pupae, and adults were recorded after treatment with all tested oils.

**Conclusion** The results suggest that oils may represent new and safe potential insecticides for the control of blowflies.

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**Introduction**

The larva of the blowfly, *Lucilia sericata* (Meigen) (Diptera: Calliphoridae), is a facultative ectoparasite infesting suppurative wounds of humans, and animals, and leading to myiasis – infestation with fly larvae.

*Lucilia sericata* is found in wounds and natural orifices of humans and animals, particularly the mouth, eyes, and sinuses. It causes itching, pain, inflammation, eosinophilia, erythema, and sometimes secondary bacterial infections.

In humans, the myiasis due to *L. sericata* was reported in 1826 by Meigen for the first time from a hospital patient.

Initial infestation and feeding activity of the larvae at the skin surface can lead to further oviposition, debilitation, and subsequent death in the case of neglect, as a result of the development of chronic ammonia toxicity. In addition, the larvae and adults of *L. sericata* act as passive vectors of Mycobacterium avium ssp. avium, Mycobacterium avium paratuberculosis, and Mycobacterium avium hominis suis.

In humans, myiasis is a relatively frequent occurrence in rural regions, where people are in close contact with domestic animals. Most patients originate from the poor stratum of society, dwelling in overcrowded, fly-infested premises that are often unsuitable for habitation. Nosocomial myiasis in hospitalized patients occurs with moderate frequency. Bedridden patients with open wounds or sores may become infested if flies are present.

Accordingly, blowfly control is important, and has relied on the use of organophosphate and synthetic pyrethroid dips and sprays, as well as insect growth regulators (IGRs). As a result of concern over human safety and environmental contamination associated with the reliance on neurotoxic insecticides, and over the development of resistance, however, further approaches to blowfly control should be evaluated.

Botanical insecticides are relatively harmless to nontarget organisms, including humans, and are also biodegradable and harmless to the environment. Medicinal and herbaceous plants have been used to control insects. Some plant extracts have been shown to be effective in controlling *L. sericata*. In addition, the applied oils fenugreek, mustard, and celery show an insecticidal effect on certain insects of medical and veterinary importance.

Because the applied oils are being tested against *L. sericata* for the first time, *in vitro* assays are useful to prescreen their efficacy. The aims of this work were to determine the insecticidal effects of four medicinal plant oils on the third larval instars of *L. sericata* following oral treatments, and the effect of...
The Notes for Guidance published by the Working Party on Myiasis is a medical and veterinary problem that affects human welfare and the economy. Lucilia sericata is distributed throughout the world, infesting humans in America, Africa, and Asia. Adult L. sericata are seen in unclean areas, slaughterhouses, and butcher shops. The female lays eggs in meat, fish, animal corpses, the infected wounds of humans and animals, and excrement.

In the vast majority of cases of human myiasis, especially in adults, local factors, such as inflammatory and malignant disease, and general factors, including psychiatric illness, senile debility, mental subnormality, and alcoholism, are important predisposing factors.

Ovine cutaneous myiasis remains the most prevalent ectoparasite-mediated disease of domestic sheep in the majority of sheep-rearing areas of the world. In this study, we have revealed the insecticidal effect of the applied oils against L. sericata for the first time, together with the inhibition of development at sublethal concentrations. The Notes for Guidance published by the Working Party on Myiasis is a medical and veterinary problem that affects human welfare and the economy. Lucilia sericata is distributed throughout the world, infesting humans in America, Africa, and Asia. Adult L. sericata are seen in unclean areas, slaughterhouses, and butcher shops. The female lays eggs in meat, fish, animal corpses, the infected wounds of humans and animals, and excrement.

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the Efficacy of Veterinary Medicines or Products (European Commission III/3682/92-EN) indicate that the overall efficacy of ectoparasiticides for the treatment of infestations by diptera species should be between 80 and 100%, preferably more than 90%. The efficacy of the applied oils met these criteria for the applied ingestion assays.

 Blowfly infestations have been controlled previously through the prophylactic use of neurotoxic insecticides, such as diazinon, high cis-cypermethrin, α-cypermethrin, deltamethrin, and IGRs, for instance cyromazine, dicyclanil, and diflubenzuron. In spite of their efficacy in the past, established control methods have become ineffective as a result of the emergence of widespread resistance to insecticides and IGRs. Moreover, the growing concern over the effect of these insecticides on the environment has led to tighter legal restrictions on their use.

Over the past few years, the potential of certain plant compounds as larvicides, adulticides, and repellents has been

### Table 2 The effect of fenugreek and celery on some biological factors of *Lucilia sericata*

<table>
<thead>
<tr>
<th>Materials</th>
<th>Concentration %</th>
<th>Pupation rate</th>
<th>Adult emergence</th>
<th>M/F</th>
<th>Deformation %</th>
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<td>100.00 a</td>
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<td>0.00 e</td>
</tr>
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<td>1.1:1</td>
<td></td>
<td>0.00 e</td>
</tr>
</tbody>
</table>

Mean within column followed by the same letter are not significantly different (P > 0.05, Duncan’s multiple range test). M/F means male/female ratio.

*L. sericata* larvae were subjected to the applied oils through an ingestion assay. 60 larvae were used for each concentration.

### Table 3 The effect of radish and mustard on some biological factors of *Lucilia sericata*

<table>
<thead>
<tr>
<th>Materials</th>
<th>Concentration %</th>
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<th>Adult emergence</th>
<th>M/F</th>
<th>Deformation %</th>
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<tr>
<td>Control</td>
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<td>93.33 a</td>
<td>1:2:1</td>
<td></td>
<td>0.00 f</td>
</tr>
</tbody>
</table>

Mean within column followed by the same letter are not significantly different (P > 0.05, Duncan’s multiple range test). M/F means male/female ratio.

*L. sericata* larvae were subjected to the applied oils through an ingestion assay. 60 larvae were used for each concentration.
investigated. Similar to our results, several botanical extracts have been demonstrated to have a larvicidal effect against *L. sericata* larvae and to retard larval growth at lower concentrations. Such plants include American wormseed (*Chenopodium ambrosiodes*) and thyme (*Thymus vulgaris*); the volatile oils dill (*Anethum graveolens*), and barnoof (*Conyza dioscoridis*) (LC50 values of 80, and 180 p.p.m., respectively); and the commercial neem extracts Neem Azal T/S, Nivaar, and Bio Dux (LC50 values of 1.3%, 0.4%, and 4%, respectively).

With regard to the effect of botanical insecticides against other myiasis-producing insects, New Zealand gymnosperms, such as *Podocarpus nivalis*, are effective against the first larval stage of *L. cuprina*. Furthermore, winged senna (*Cassia alata*) and betel leaf (*Piper betle*) show larvicidal effects against *Chrysomya megacephala*. Strong retardation of the larval development of *Parasarcophaga aegyptiaca* is caused by dill, barnoof extracts (LC50 values of 70, 84, and 150 p.p.m., respectively). It is possible that the assay methods, species’ differences, and exposure time to test substances may be responsible for the variations between the assay outcomes.

The pupation rates and adult emergence were strongly affected after the treatment of larvae with sublethal concentrations. Comparable inhibitions have been recorded for many plants, such as neem extracts against *L. sericata*, pomegranate (*Punica granatum*) against *chrysomya albiceps*, and clove (*Eugenia aromatica*) and thevetia (*Thevetia peruviana*) oils against *P. aegyptiaca*.

With regard to the sex ratios, there was a skew towards males after treatment with sublethal concentrations, which, eventually, will lead to population decline. Similar observations have been recorded after treatment of *Musca domestica* with the plant oils sesame (*Sesamum indicum*) (3.7 : 1), nigella (*Nigella sativa*) (2.3 : 1), and onion (*Allium cepa*) (1.7 : 1), and the IGRs diflubenzuron (5.0 : 1) and pyriproxifen (3.3 : 1). Furthermore, the sex ratios were affected slightly following treatment of *P. aegyptiaca* with thevetia and clove oils (1.2 : 1).

Several plant extracts induce similar larval and pupal abnormalities of myiasis-producing flies, e.g. pomegranate, New Zealand gymnosperms, dill, barnoof, clove, and thevetia oils. Comparable abnormalities have been recorded for *M. domestica* after treatment of the third larval instars with sesame, nigella, onion, diflubenzuron, and pyriproxifen. The abnormalities could be attributed to the metamorphosis-inhibiting effect of plant oils, as a result of the disturbance of hormonal control, suggesting a type of insect growth-regulating activity.

The presence of larviform puparia could result from the failure of larvae to contract to the pupal form, as a result of muscle paralysis, but their ability to acquire melanization of the pupal cuticle, because of the continuation of the enzymatic process of tanning.

The failure of adult emergence could occur as a result of a combination of two or more of the following factors: unsaturated fatty acids, which accelerate the process of melanization.

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Figure 1 Morphological malformations which were recorded after treatment with oils

I. Deformed larvae
   1 – Small-shrunken larva with diffuse brown pigment.
   2 – Weak cuticle with ulceration (arrow head).
   3 – Weak cuticle with ulceration (arrow heads) and patches of brown pigment.
   4 – Twisted larva with diffuse brown pigment.

II. Pupal malformations
   1 – Puparium with abnormal eclosion fissure.
   2 – Larviform puparium.
   3 – Small-cracked puparium with central groove (arrow head).
   4 – Small and distorted puparium.

III. Adult abnormalities
   1 – Adults and deformed wing and legs.
   2 – Deformed wing, and legs.
   3 – Crumpled wing, and deformed legs.
   4 – Small, crumpled-poorly developed adult.
and hardening of the larvae (thus adults are unable to extricate themselves from the pupal excuviae); insufficient pressure in the ptilinum; and hardening of the opercular suture.\textsuperscript{14}

The applied oils have insecticidal effects against several other insects. Fenugreek and mustard are potential natural larvicides and have adverse effects on the pupae and adults developing from surviving larvae of \textit{Culex pipiens}. The LC\textsubscript{50} values are 234.05, 32.42, and 71.37 p.p.m., for chloroform extract of fenugreek,\textsuperscript{21} fenugreek, and mustard oil,\textsuperscript{44} respectively.

Fenugreek has adverse effects on third larval instars and adult fecundity of \textit{M. domestica}.\textsuperscript{18} In addition, oviposition avoidance or deterrence was exhibited by gravid \textit{Aedes aegypti} to ovitraps baited with fenugreek and radish.\textsuperscript{18}

Fenugreek induces several forms of morphologic malformation after treatment of the fourth larval instars of \textit{C. pipiens}. Such abnormalities include pigmented, twisted larvae and larval–pupal intermediates. Pupal and adult abnormalities include albino, elephantoid, pupae with a blackish cephalothorax, failure of adult eclosion, and deformed abdomen and legs.\textsuperscript{44}

Furthermore, fenugreek has an insecticidal effect against the cotton leaf worm, \textit{Spodoptera littoralis}.\textsuperscript{44} Moreover, topical application produced a high mortality, inhibited oviposition and larval penetration, and decreased fecundity, fertility, and longevity of two stored product pests: \textit{Tribolium castaneum} and \textit{Acanthoscelides obtectus}.\textsuperscript{39}

Mustard is highly effective against larvae of \textit{Aedes aegypti}.\textsuperscript{59} In addition, an emulsion of mustard oil, tobacco leaf extract, dichlorodiphenyltrichloroethane (DDT), copper sulfate, and water has been used to control ticks, including \textit{Boophilus}.\textsuperscript{15}

Crude seed extract of celery possesses larvicidal, adulticidal, and repellent activities against \textit{Ae. aegypti}.\textsuperscript{39} In addition, the methanolic extract of celery seeds contains bioactive compounds that express mosquitocidal activity, such as sedanolide, senkyunolide-N, and senkyunolide-J.\textsuperscript{11}

It is worth mentioning that the feeding activity of \textit{L. sericata} larvae may lead rapidly to further oviposition by other flies, debilitation, and chronic ammonia toxicity, which may give rise to death, unless treated.\textsuperscript{13} Consequently, the deterrent effect of fenugreek,\textsuperscript{35,59} celery,\textsuperscript{36} and radish\textsuperscript{19} oils could decrease the abundance of blowflies as a form of prophylaxis against myiasis.

For the prevention of myiasis caused by blowflies, especially hospital-acquired infestations, the maintenance of clean dressings on wounds will stop infestation, fly screens can be placed over the windows to prevent fly entry, and fly electrocutors can be installed on the walls in rooms and corridors to kill any flies that do enter.\textsuperscript{7}

The larvae and adults of \textit{L. sericata} may participate in the spread of the causal agents of mycobacterial infections, and this should be considered during the sanitation of infected herds and in slaughterhouses, when materials from animals infected by mycobacterial infections are processed.

For human safety, myiasis-producing flies should be controlled, especially around slaughterhouses and sheep farms. Moreover, botanical control may be supported by farm management practices, such as tail docking, shearing, appropriate control of gastrointestinal nematodes, and the removal of fecal-soiled wool, all of which are predisposing factors.

**Conclusions**

Blowflies must be safely controlled to avoid myiasis and diseases transmitted to both humans and animals.

The activity of the oils used extends beyond the larval stage. They kill larvae when used at high concentrations, and lead to a series of morphologic abnormalities that inhibit metamorphosis. Consequently, they may prevent adult emergence and protect against re-infestation.

These inexpensive and readily available plant oils are more easily degradable, more species specific, and less susceptible to the development of resistance than are the currently used synthetic pesticides. They may lead to the future development of potential natural insect control agents, which could be evaluated in the field and integrated into other pest management programs for the control of blowflies.

**Acknowledgments**

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**References**


Oils as insecticides against blowflies

Tropical medicine rounds

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