



# Insecticidal Activity Of Lemongrass Essential Oil Against The Silverfish, *Lepisma Saccharina*

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## ABSTRACT

Various biological agents are responsible for the enormous damage to all preserved museum specimens, herbarium and historical books. Among these biological agents, silverfish are well-known pests that cause serious problem in libraries, museum and other places where books, documents and herbarium are stored. Therefore in this study, lemongrass essential oil was investigated insecticidal activity against adult silverfish. Insecticidal bioassay results of lemongrass essential oil indicated that the mortality of adult silverfish was not recorded when they treated with all concentration for 30-minutes. But with increasing oil concentration and treatment duration, the number of silverfish decreased and maximum mortality was recorded at higher oil concentration and higher treatment duration. The number of adult silverfish decreased with increasing the treatment duration when concentrations were constant except 0.3-ml lemongrass essential oil concentration. The percentage reduction over control was increased with increasing oil concentration and treatment duration, but a more effect on ROC (%) was observed when adult silverfish were treated for longer than 60 minutes treatment duration. ROC (%) showed a minimum increase when adult silverfish were treated for 30, 60, 90 and 120-minutes with 0.3-ml and maximum with 0.9-ml oil concentrations, respectively.

**Keywords:** Lemongrass essential oil concentration, silverfish, contact and fumigant toxicity treatment duration.

## INTRODUCTION

Among all biological agents, most of the insects are one of the major notorious pests for all collected specimens in libraries, houses and museum institutions<sup>[1]</sup>. These notorious pests such as silverfish, booklice (*Lipocelis bostricophila*), furniture beetle (*Anobium punctatum*), biscuit beetle (*Stegobium panicum*), tobacco beetle (*Lasioderma sericorn*), cockroach (*Periplaneta americana*) and carpet beetle (*Anthranus verbasi*) commonly cause enormous damage to museums and libraries all around the world<sup>[2]</sup>. Whereas microbial, chemical and physical factors were also damage the herbarium specimen during the various stages of herbarium preparation<sup>[3]</sup>. Several herbarium collections were inspected at various institutions to ascertain the nature of degradation and problems related to their conservation, and concluded that conservators of libraries, museums, archives and curators were aware of the problems of herbarium degradation and conservation. Scientific methods have helped not only in ascertaining type and extent of decay, but also in their technical knowledge to a great extent<sup>[4]</sup>. Primarily, insect pests were controlled to continue applied of chemical and synthetic insecticides not only museums but also huge amount used in agriculture fields in all over the world<sup>[5]</sup>. If any sample has not deteriorated through biodegradation over the

years, it is clear that the specimens have been chemically treated<sup>[6]</sup>. The continuously used of chemicals have shown disadvantages in respect to risk of human health, residual toxicity and development of resistance in many insect species<sup>[7]</sup>, that why entomologists do not suggested that the chemical insecticides be used for pest management<sup>[8]</sup>, and instead advocate controlling numbers by reducing humidity and focusing on heating or freezing infected objects<sup>[9]</sup>. But it is impossible to many places keep the entire environment under low humidity, especially in museums, houses and libraries. Therefore, it is necessary to makes alternative methods for controlling the pest populations, and these alternative methods should be cost effective, readily available, environmentally friendly, beneficial and harmless.

Thousands of years ago in India, various plant products were used as traditional medicine for pest control. They are not only healthy but also cost effective and eco-friendly. In which the plant extracts provide a vast, virtually untapped storehouse of chemical compounds with many potential uses. Many researchers use the bio-based materials in controlling the underground termites and their potential availability and variability<sup>[10]</sup>, and these essential oil to have an insecticidal, anti-bacterial, antifungal, anticarcinogenic, antimutagenic properties<sup>[11]</sup>. Previous studies suggest that since ancient times lemongrass, *Cymbopogon* species used worldwide as the most powerful natural repellent<sup>[12]</sup>, insecticidal<sup>[13]</sup>, antifungal<sup>[14]</sup>, antimicrobial<sup>[15]</sup> and therapeutic properties<sup>[16]</sup>. The essential oils of *C. martini* yielded 100% repellency against anopheles and other mosquito species in a field apply for 12-hours<sup>[17]</sup>. The essential oil of *C. winterianus* mixed with 5% vanillin gave 100% repulsion against *Aedes aegypti*, *Culexquinque fasciatus* and *Anopheles dirus* at 6-hours<sup>[18]</sup>.

The characteristic insecticidal and repellent properties of lemongrass essential oils can be used in pest management schemes<sup>[19]</sup>. <sup>[20]</sup>found that lemongrass oil had a moderate effect against the stored grain pests. From the previous reference review, we can conclude that lemongrass essential oils can be used to control museum pest population. Therefore, this investigation is to investigate the effects of different concentrations of lemongrass essential oil with various treatment durations against the silverfish population in museum.

## MATERIALS AND METHODS

### STOCK CULTURE

*L. saccharina* adults were collected from the basement of Maulana Azad Library and Department of Museology, AMU., Aligarh (27.88°N 78.08°E), UP, India. They were reared in plastic containers (15×20×10cm<sup>3</sup>; 10-adults/container), and provided a limited amount of cellulose containing mixed food (milk powder, oatmeal, yeast; 1:9:1) in a 1:1 ratio which was replenished daily. All above setup was placed at 25°±3°C temperature and 90% relative humidity in the dark place. Silverfish individual were added from time to time in the laboratory culture to avoid inbreeding depression, and colony had been established at least 2-3 years before the study. This study was done in Department of Museology laboratory, Aligarh Muslim University, Aligarh.

### EXPERIMENTAL DESIGN

#### a. CONTACT INSECTICIDAL ACTIVITY

The adults were taken from the laboratory stock culture. The essential oils of lemongrass were selected for this study and prepare three different concentrations (0.3, 0.6 and 0.9-ml) with the help of FILTER PAPER BIOASSAYS. To evaluate the insecticidal activity of lemongrass essential oil, the 0.3-ml oils were applied on filter papers (2 × 2cm<sup>2</sup>) and then placed into Petri dishes (9cm diameter × 1.0 cm height) that contained ten adult silverfish. A few drops of water were put onto the bottom edge of Petri dish. These Petri dishes were placed in a BOD (Biological Oxygen demand) to maintain the above condition. The number of individual dead and percentage reduction over control (ROC %) was recorded periodically for up to 30, 60, 90 and 120-minutes. The same experiment was also repeated in 0.6 and 0.9-ml concentration of lemongrass essential oil and above observation was recorded. To control condition, they exposed to filter paper treated with normal water. The whole experiments were repeated ten times.

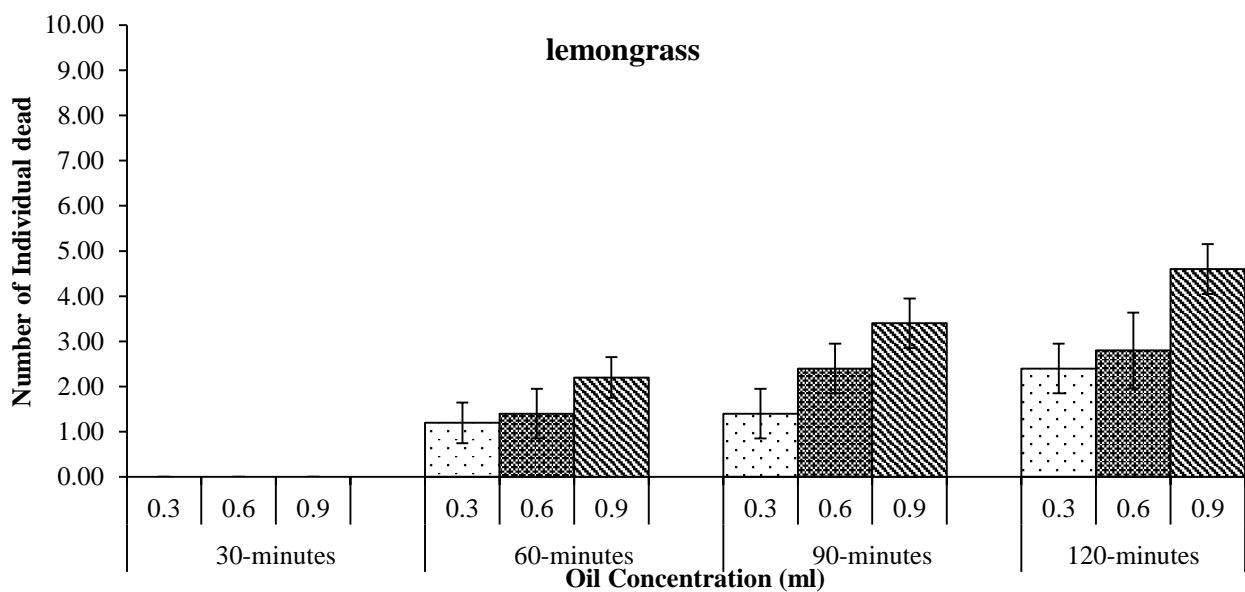
**b. FUMIGANT INSECTICIDAL ACTIVITY**

Adults of silverfish were released in the above mention size Petri dish with a 2-cm diameter cotton ball treated with 0.3-ml essential oil. To prevent direct contact of silverfish with essential oil, 0.3-ml concentrated oil was injected to the center of cotton ball. The same experiment was repeated in 0.6 and 0.9-ml concentrated lemongrass oils. In control condition, they exposed to cotton ball treated with normal water. The numbers of individual death and ROC (%) was recorded at above mention treatment duration.

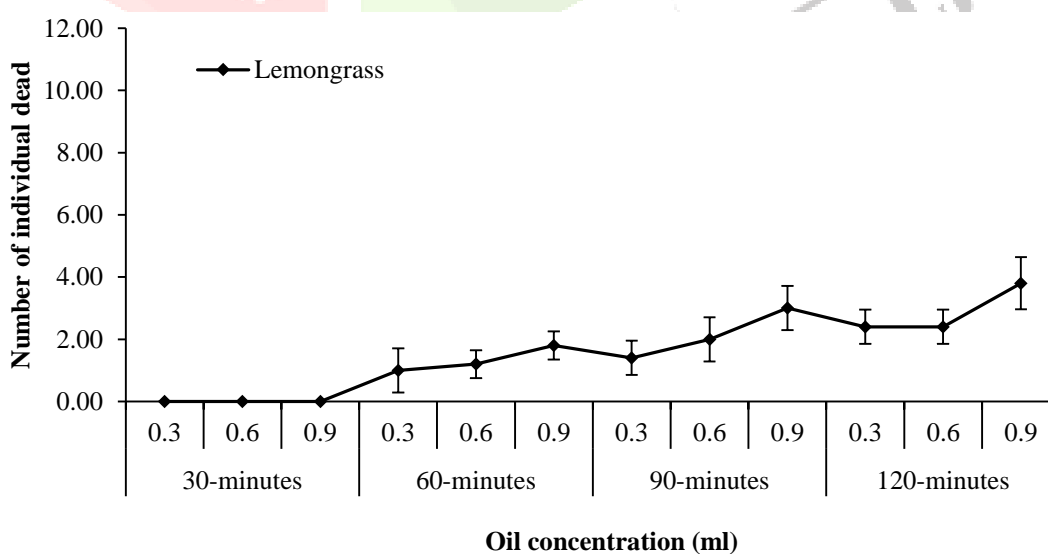
**STATISTICAL ANALYSIS**

Data obtained on number of individual mortality were analyzed using two-way ANOVA followed by posthoc Tukey’s test with different oils, and oils concentration (0.3, 0.6 and 0.9 ml) as independent factors. All analyses were carried out using MINITAB-16 statistical software (Minitab Inc., State College, Pennsylvania, USA).

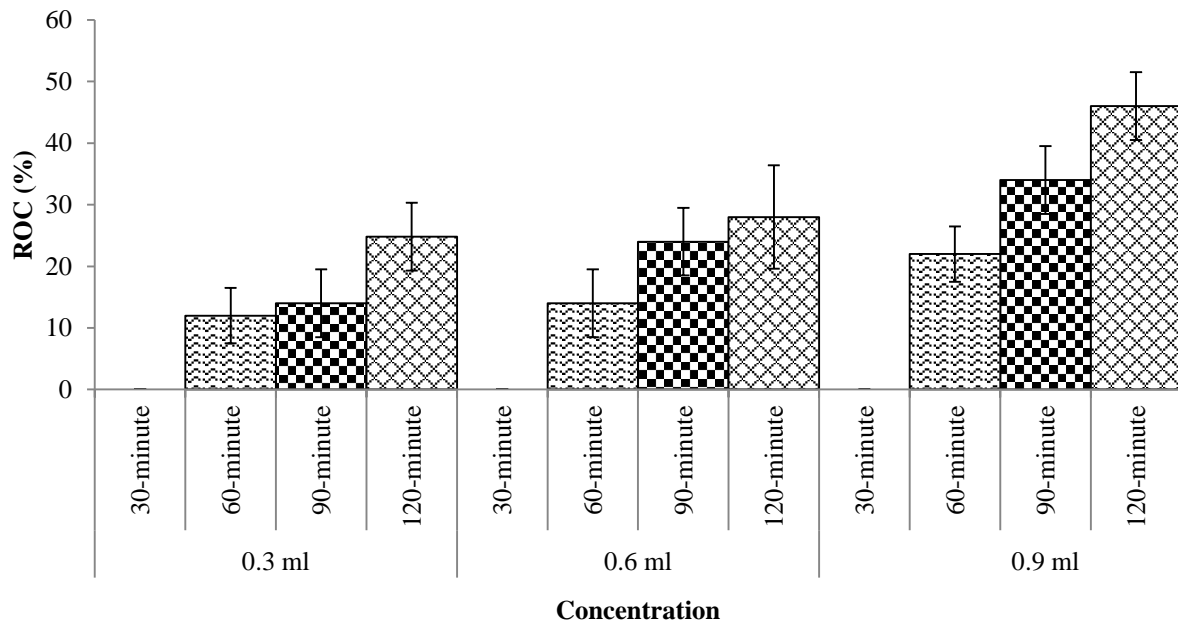
**OBSERVATION**



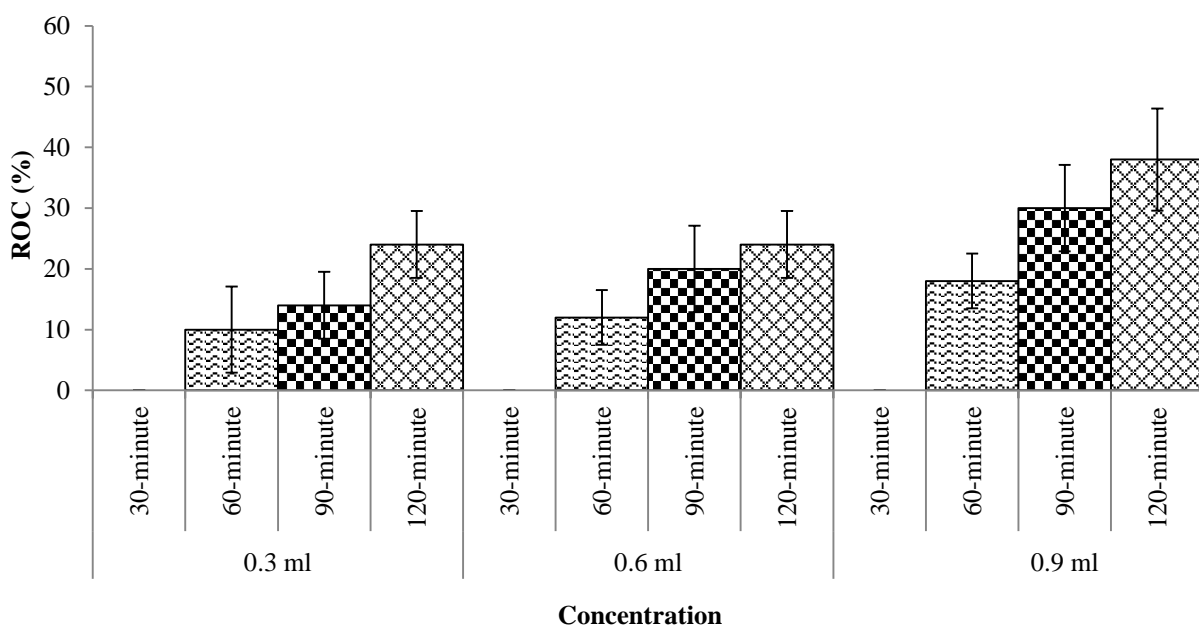
**Figure-1: Effect of various concentration (0.3ml, 0.6ml, 0.9-ml) of lemongrass oil at different treatment duration (30, 60, 90 & 120-minutes) on mortality of silverfish.**



**Figure-2: Effect of various fumigant concentrations (0.3, 0.6, 0.9-ml) of lemongrass oil at different duration of treatment (30, 60, 90 & 120-minutes) on mortality of silverfish.**



**Figure-3: Effect of different concentrations of Lemongrass essential oil at different treatment duration on ROC (%) of Silverfish.**



**Figure-4: Effect of different fumigant concentrations of lemongrass oil at different duration of treatment on ROC (%) of Silverfish.**

## RESULTS

### a. CONTACT INSECTICIDAL ACTIVITY

The result of two-way ANOVA revealed that the mortality was not significantly related to essential oil concentration ( $F=4.53$ ;  $P=0.005$ ;  $df=3, 159$ ), treatment duration ( $F= 5.65$ ;  $P=0.001$ ;  $df=3, 159$ ), and interaction between the two independent factors ( $F=0.86$ ;  $P=0.562$ ;  $df=9, 159$ ). No mortality was recorded in adult silverfish treated with the all concentration of lemongrass essential oil for 30-minutes. The number of individuals decreased with increasing treatment duration at all lemongrass oil concentrations, and the difference was negligible. Maximum mortality was recorded at higher treatment duration (120-minutes with higher oil concentration (0.9-ml). It was also observed that the number of adult silverfish decreased with increasing treatment duration only when the oil concentration was constant. These properties were recorded at all oil concentrations except for the 0.3-ml lemongrass essential oil. (Figure-1). ROC (%) increased with increasing treatment duration at all oil concentrations. It was also observed that the increase of ROC (%)

was effectively recorded after a treatment period of 60 minutes. Minimum ROC (%) was recorded at 0.3-ml and maximum at 0.9-ml oil concentration for 30, 60, 90 and 120-minutes (Figure-3).

## b. FUMIGANT INSECTICIDAL ACTIVITY

Result revealed that the individual mortality was not recorded when they treated with 0.3, 0.6 and 0.9-ml essential oil concentration for 30-minutes. There was an increase in mortality of adults silverfish incubated for 60, 90 and 120-minutes with 0.3, 0.6 and 0.9-ml oil concentrations. Maximum adult mortality was recorded at high treatment duration with higher dose applied (Figure-2). The two-way ANOVA revealed that the mortality was not significantly affected by oil concentration ( $F=4.53$ ;  $P=0.005$ ;  $df=3, 159$ ), and treatment duration ( $F= 5.65$ ;  $P=0.001$ ;  $df=3, 159$ ). The interaction between the two independent factors was also insignificant ( $F=0.86$ ;  $P=0.562$ ;  $df=9, 159$ ). It was also observed that with increasing oil concentration and treatment duration there was an increase in ROC (%) as well. The ROC (%) increased with increasing treatment duration at all oil concentrations. ROC (%) minimum 0.3-ml and maximum 0.9-ml oil concentration were recorded after 30, 60, 90 and 120-minutes of treatment (Figure-4).

## DISCUSSION

In the present study, some experiments were conducted and found that the mortality rate of adult silverfish increased with the increase of lemongrass essential oil concentration and treatment duration. The mortality is greatly affected by oil concentrations, and the degree displayed as well as depends on the treatment duration. The highest mortality was reported in the presence of high doses over the maximum treatment duration. The ROC (%) also increased with increase the oil concentration and treatment duration.

The present study highlights the importance of using essential oils in the control of silverfish populations. Insecticidal and repellent action of lemongrass essential oil against silverfish was detected in bioassays under laboratory conditions. Topically applied lemongrass was toxic against silverfish adults and increased mortality in a dose-dependent manner, as with other insects<sup>[21]</sup>. Much attention is being paid to finding alternative components, one of which is essential oils that are environmentally friendly and ecologically safe<sup>[22]</sup>. Among this essential oil, lemongrass oil is known to be a potent and strong insect repellent, which is used in aromatherapy and perfumery<sup>[23]</sup>. Insecticidal activities of lemongrass essential oils have also been reported against several agricultural and non-agricultural pests<sup>[24]</sup>. The oils generally contain biogenetically related phenols, composed of a complex mixture of monoterpenes and sesquiterpenes. It has been reported that 1, 8-cineole is the major constituent of rosemary and eucalyptus oil; menthol, citral and limonene from lemongrass oil<sup>[11]</sup>. A number of studies report that essential oils are used as insecticidal activity against the museum pests<sup>[25]</sup>.

The Lemongrass petroleum or ether extract showed approximately 60-80% repellency percentage against Silverfish<sup>[26]</sup>. Traditionally the grass of *Cymbopogon* species have been used for repel mosquitoes, *in vitro* activity against *Candida* spp, and antimicrobial against some oral microorganism *S. mutans*, *P. intermedia* and *P. gingivalis*<sup>[27]</sup>. But some other studies also proved that not all species of *Cymbopogon* are always effective for other insect. For example two species *C. nardus* and *Cymbopogon flexuosus* oil were ineffective on *Cigarette beetle* and *Lasioderma serricorne*<sup>[28]</sup>.

There are fewer reports of lemongrass oil being effective against silverfish, but several previous studies against various other pests have been reported<sup>[25,29]</sup>. Lemongrass essential oil after exposure by contact or fumigation shows that topical application of varying doses of small amounts of lemongrass essential oil can protect against *S. granaries*. One set of results point to toxic effects of lemongrass essential Oil on insect pests with an LC50 of 35.133 mg/L against third-instar larvae of *Aedes aegypti* mosquitoes<sup>[30]</sup>, 0.268 ppm *Phthoremiao perculella*<sup>[31]</sup>, and against the adult insect of 7.07 ppm against the adult stage of cowpea mite *Calosobruchus maculatus*<sup>[32]</sup>. Thus, lemongrass essential Oil has shown toxic effects on adults of *Cytophilus granarias*<sup>[19]</sup>.

This study shows the potential of lemongrass essential oil as an insecticide or repellent integrated pest management approach to manage silverfish population. These essential oils caused significant effects on the mortality, and ROC (%) in this pest of museum. Additionally, insecticidal potential increased with increasing the treatment duration at all lemongrass oil concentrations and maximum mortality at higher treatment duration with higher oil concentration.

## ACKNOWLEDGEMENT

The authors are thankful to University Grant Commission for providing research grant and department of Museology, Aligarh Muslim University for providing infrastructures.

## REFERENCES

- [1] Alam, I. 1989. Bionomics and control of *Lepisma saccharina* (Thysanura). National Research Laboratory for Conservation of Cultural Property (NRLC) Pub, Lucknow.
- [2] Pinniger, D. 1994. *Insect Pests in Museums*, Archetype, London.
- [3] Kowalik, R. 1980. Microbiodeterioration of library materials. *Restaurator*, Denmark, Munksguard international publishers, 4: 99-114.
- [4] Agarwal, O.P. and Dhawan, S. 1985. Control of biodeterioration in museums. Technical note. NRLC, Lucknow. 2.
- [5] Alzogaray, R.A., Lucia, A., Zerba, E.N. and Masuh, H.M. 2011. Insecticidal activity of essential oils from eleven *Eucaliptus* spp. and two hybrids: lethal and sublethal effects of their major components on *Blatella germanica*. *Journal of Economic Entomology*, 104:595-600.
- [6] Sohel, M.d., Rana, M.d. and Yaakob, Z. 2017. Study of chemical composition and medicinal properties of volatile oil from clove buds (*Eugenia caryophyllus*). *International Journal of Pharmaceutical Sciences and Research*, 8(2): 895-899.
- [6] McGregor, C., Mackay, H. and Roach, A. 2011. To bag or not to bag? Treatment of a large Solomon Island war canoe and the growing threat of drywood termites to collections in Australia. *Historic England Press*.
- [7] Cornwell, P.B. 1976. The cockroach, 2, *Assoc Bus.Prog.*, London. Pp 557.
- [8] Cheng, S.S., Lin, H.Y. and Chang, S.T. 2005. Chemical composition and antifungal activity of essential oil from different tissues of Japanese cedar (*Cryptomeria japonica*). *Journal of Agricultural and Food Chemistry*, 53: 614-619.
- [9] Slater, A. and Kastanis, G. 1977. *Silverfish and firebrats: How to control them*. Development of agriculture science. University of California.
- [10] Safian, A., Sajap, A.S., Sukari, M.A., Abu-Bakar, N.H., Harris, F.A. and Kassim, R.M. 2011. Effects of leaf extracts of *Murraya koenigii* (Rutaceae) on *Coptotermes curvignathus* (Isoptera: Rhinotermitidae). *Sociobiology*, 57: 291-300.
- [11] Isman, M.B. 2000. Plant essential oils for pest and disease management. *Crop Protection*.19: 603-608.
- [12] Baldacchino, F.V., Tramut, C., Salem, A., Lienard, E., Deletre, E., Franc, M., Martin, T., Duvallet, G. and Jay-Robert, P. 2013. The repellency of lemongrass oil against stable flies, tested using video tracking. *Parasite*, 20-21.
- [13] Aziz, E.E. and Abbas, M.H. 2010. Chemical composition and efficiency of five essential oils against the Pulse beetle *Callosobruchus maculatus* F on *Vigna radiata* seeds. *American Eurasian. J. Agric. Environ. Sci*, 8: 411-9.
- [14] Isman, M.B. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual review of entomology*, 51: 45-66.
- [14] Matasyoh, J.C., Wagara, I.N., Nakavuma, J.L. and Kiburai, A.M. 2011. Chemical composition of *Cymbopogon citratus* essential oil and its effect on mycotoxigenic *aspergillus* species. *African Journal of Food Science Research*, 5:138-42.
- [15] Syed, M., Qamar, S., Riaz, M. and Chaudhary, F.M. 1995. Essential oils of the family Gramineae with antibacterial activity. Part 2: the antibacterial activity of a local variety of *Cymbopogon citratus* oil and its dependence on the duration of storage. *Pakistan Journal of Scientific and Industrial Research*, 38: 146-148.
- [16] Shah, G., Shri, R., Panchal, V., Sharma, N., Singh, B. and Mann, A.S. 2011. Scientific basis for the therapeutic use of *Cymbopogon citratus*, stapf (Lemongrass). *Journal of Advanced Pharmaceutical Technology and Research*, 2: 3-8.
- [17] Ansari, M.A. and Razdan, R.K. 1994. Repellent action of *Cymbopogon martini* Stapf. var. *Sofia* against mosquitoes. *Indian journal of malariology*, 31:95-102.
- [18] Tawatsin, A, Wratten, S.D., Scott, R.R., Thavara, U. and Techadamrongsin, Y. 2001. Repellency of volatile oils from plants against three mosquito vectors. *Journal of Vector Ecology*, 26(1):76-82.

- [19] Plata-Rueda, A., G. D. S. Rolim, C. F. Wilcken, J. C. Zanuncio, J. E. Serrao 2020. Acute toxicity and sublethal effects of lemongrass essential oil and their components against the granary weevil, *Sitophilus granarius*. *Insects*, 11(6): 379.
- [20] Binseena, S.R., Anitha, N., Paul, A., Amritha, V.S. and Anitha, K.N. 2018. Management of rice weevil, *Sitophilus oryzae* using essential volatile oils. *Entomon*, 43(4): 277-280.
- [21] Machial, C.M., Shikano, I., Smirle, M., Bradbury, R. and Isman, M.B. 2010. Evaluation of the toxicity of 17 essential oils against *Choristoneura rosaceana* (Lepidoptera: Tortricidae) and *Trichoplusia* (Lepidoptera: Noctuidae). *Pest Management Science*, 66: 1116-1121.
- [22] Jung, C., Seog, H., Choi, I. and Cho, H. 2005. Antioxidant activities of cultivated and wild Korean ginseng leaves. *Food Chemistry*, 92(3): 535-540.
- [23] Amer, A. and Mehlhorn, H. 2006. Repellency effect of forty-one essential oils against *Aedes*, *Anopheles*, and *Culex* mosquitoes. *Parasitological Research*, 99: 478-490.
- [24] Ishii, T., Matsuzawa, H. and Vairappan, C.S. 2010. Repellent activity of common spices against the rice weevil, *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae). *Journal of Tropical Biology & Conservation*, 7: 75-80.
- [25] Nasrin, S., Shahid, M. and Abduraheem, K. 2021. Repellency action on Silverfish (*Lepisma saccharina*) of some essential oils like *Azadirachta Indica* and *Mentha*. *Journal of scientific engineering and applied science*. 7:11. 60-72.
- [26] Kumar, S., Singh, K. and Dwivedi, N.K. 2017. Repellent effect of three plants *curcuma longa*, *Cymbopogon citratus*, *Adhatoda vasica* against insect pest Silverfish, *Acrotelsa collaria* (Fabr) (Thysanura: Lepismatidae). *World journal of Pharmaceutical Research*, 6(5): 1518-1527.
- [27] Moore, S.J., Hill, N., Ruiz, C. and Cameron, M.M. (2007). Field evaluation of traditionally used plant-based repellents and fumigants against the malaria vector *Anopheles darlingi* in Riberalta, Bolivian Amazon. *Journal of Medical Entomology*, 44: 624-430.
- [28] Oyedele, A.O., Gbolade, A.A., Sosan, M.B., Adewoyin, F.B., Soyelu, O.L. and Orafidiya, O.O. 2002. Formulation of an effective mosquito-repellent topical product from lemongrass oil. *Phytomedicine*, 9: 259-262.
- [29] Nasrin, S., Shahid, M. and Abduraheem, K. 2021. Insecticidal activity of Peppermint and Nutmeg essential oil against the museum pest Silverfish. *Journal of emerging technologies*, 8(8): 605-616.
- [30] Kurniasih, N., Nuryadin, W., Harahap, M.N., Supriadin, A. and Kinasih, I. 2015. Toxicity of essential oils from orange (*Citrus sinesis* L. Obbeck) and lemongrass (*Cymbopogon nardus* L. Rendle) on *Aedes aegypti* a vector of Dengue Hemorrhagic Fever (DHF). *Journal of Physics: Conference Series*, 1869, 01.
- [31] Jovanovic, J., Krnjajic, S., Cirkovic, J., Radojkovic, A., Popovic, T., Brankovic, G. and Brankovic, Z. 2020. Effect of encapsulated lemongrass (*Cymbopogon citratus* L.) essential oil against potato tuber moth *Phthorimaea operculella*. *Crop Protection*, 132: 105-109.
- [32] Omotoso, S.E., Akinpelu, B.A. and Soyelu, O.J. 2020. Insecticidal effect of lemongrass oil on behavioural responses and biochemical changes in cowpea weevil, *Callosobruchus maculatus* (Fabricius). *Journal of Phytopathology and Pest Management*, 7: 14-30.