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Insecticidal activities of some essential oils against American cockroach *Periplaneta americana* (L.)

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Abstract

The inhibition of survival of adult cockroach was investigated under laboratory conditions. We assessed the extent to which survivability was affected by nature of oil, oil concentration and exposed duration. The results show that the number of adult cockroach survivability decreased with increasing the concentration of oil, except 1-hrs, and also observe that the various oil and exposed duration have affected the survivability, and maximum number of adult inhibition was reported in higher concentration of all oils, and 100 % mortality was reported in Nutmerg and clove oils. While in case of exposed duration of all essential oil, the adult survivability decreased with increasing the duration at all essential oils.

Keywords: oils, oil concentration, exposed duration and adult survival.

Introduction

In India, *P. americana* is a common household pests and usually found in baits, sewers, basements, Libraries, museums, hospitals, restaurants, buildings and schools (33). They are omnivorous and feed on leather, paper, glues, animal skins, hair and wool fabrics, especially if the above item is stained with food and sweat. For long, cockroaches have been recognized as mechanical vector such as bacteria, viruses, protozoan and helminthes and causes different types of diseases and allergies (10,23,11,4,5) that's why its control measures is very necessary. Primarily, cockroaches are controlled with continued application of chemical and synthetic insecticides (29, 2). These applications are applied all over the world. Because of long duration to continue used of these applications show some disadvantages like human health hazards, residual toxicity and development of resistance in several pest species. Various chemical such as organophosphorus, carbamate and pyrethroids have used for control the cockroach population (29). These insecticide applications restricted to increase demand for safer alternatives against cockroach infestations (32; 26). So, human health and environmental safety point of view have concern a new application developed for management the cockroach population is needed.

The essential oils responsible for the aromatic characteristics of plants, and they are considered insect-control agents and have no harmful effect on the environment and non-target organisms (13, 12, 22). The essential oils are used to a wide range of

activity against insect and mite pests, plant pathogens, fungi and nematodes (12). Various study highlighted antimicrobial, antifungal, anticancer and insecticidal properties of plant essential oils (12, 13). They have fumigants, antifeedant and repellent effects as well as inhibiting the reproduction in cockroaches and other insects (22). They could be used in areas where chemical insecticides are prohibited. Numerous studies have reported that the most of the essential oils degrade quickly and do not accumulate in the human health and environment, and some are very pest specific. Hence, essential oils from various plants may be potential alternatives component to used against the control of cockroach species (14; 35; 9; 18 ; 36; 26; 38; 20; 22).

In the present study the author have selected six essential oil like *Mentha piperita* (peppermint), *Syzygium aromaticum* (clove), *Azadirachta indica* (Neem), *Ricinus communis* (Castor oil), *Cymbopogon* (Lemon grass oil) and *Myristica fragrans* (Nutmeg) were experimented on Cockroach a herbarium pest with different concentration and for selected time duration to determine the highest mortality rate of cockroach. The whole experiments were repeated ten times for accuracy.

Experimental design

Stock maintenance

Adult of *P. americana* (twenty pairs) were collected from savage and moist places in Aligarh Muslim University Aligarh (27.88°N 78.08°E), U.P., India. They were paired and kept in Plexiglas containers and maintained at 27±2 °C, 50±5% RH, and the photoperiod of 12:12 (L: D) h, and provided with an ad-libitum supply of food (Pieces of facial tissue were provided as a harborage and surface sticking of ootheca). After egg laying, paired cockroaches were placed in an Plexiglas they hatched. The nymphs were reared in cages (25 x 35cm; 10 Nymphs per cage) and provide and abundant supply of food, which was replenished daily. The newly form adults were isolated and placed individually in cases (size as above) and thereafter used for experimental purposes. Cockroaches collected in the field were added from time to time to the laboratory culture in order to avoid inbreeding. The cockroach colony had been established at least 2–3 years before the study. The study was done in the laboratory of museum, Department of Museology, Aligarh Muslim University, Aligarh.

Collection of essential oils

The essential oils were collected from herbal market in Dodhpur, Aligarh India. These oils were placed at room temperature in a air tight glass.

Essential oils preparation

Adults were taken from the stock culture. The six essential oils of Mentha, Clove, Neem, Nutmeg, Castor, Lemongrass oils were selected for this study because all these oils were easily available in markets of tropical and sub tropical countries. All the above six essential oils were form three different concentration (0.3, 0.6 & 0.9 ml/L) with the help of filter paper bioassays. Thereafter, fallowing experimental treatments were designed:

1. Control condition
2. Sock 0.3 ml/L of Mentha Oil
3. Sock 0.6 ml/L of Mentha Oil
4. Sock 0.9 ml/L of Mentha Oil

All the above treatments were formed in Petri dish, which were sealed and placed in insectory chamber (temperature, R.H and humidity above) for 1-hrs. After every 1-hrs, the number of individuals and weight (mg) were recorded. The above treatments were repeated 12, 24 and 36 hours. All treatments were replicated 10 times, and the above experiment and treatment were also repeated with Clove, Neem, Nutmeg, Castor, Lemongrass oil.

Statistical analysis

Data obtained on number of individual survive were analyzed using two-way ANOVA followed by post hoc Tukey's test with oil concentration (0.3, 0.6 and 0.9ml/L) and exposed duration (1, 12, 24 and 36-hrs) as independent factors. All analyses were carried out using MINITAB 16 statistical software (Minitab Inc., State College, Pennsylvania, USA).

Results and Discussion

The results of two-way ANOVA revealed that the number of individual survive in each oil was affected by both oil concentration and exposed duration and there was no interaction between these two factors. In 0.3 ml/L concentration of all six essential oils, the numbers of individual survival decreased statistically significant differences were recorded between oils and exposed duration and there was significantly

interaction between oils and exposed duration (Table-1). The highest survival rate was recorded at Mentha, Neem, castor and Lemongrass and lowest was clove and Nutmeg oil. The highest mortality was recorded in clove and Nutmeg oils at 36 hrs, and 100% mortality was recorded in Nutmeg oil (figure-1). In others 0.6 and 0.9 ml/L concentration of all essential oils, the number of individual significantly decreased in oils, however, it was significantly wider in exposed duration and interaction between oil and exposed duration (Table-1). The mortality rate increased with increasing the exposed duration, and 100% mortality was recorded in clove and Nutmeg oils at 36 hrs. While in case of 0.9 ml/L concentration of Nutmeg and clove oil, the 100 % mortality was recorded at 12 hrs, and 24 and 36-hrs respectively (Table-1, Figure-1).

Table-1: Effect of varying concentration of different oils with different treatment on survival of adult *P. americana*

Concentration (ml)	Oil	Treatment duration (Hrs)			
		1	12	24	36
0.3	Mentha	9.80±0.45$^{a(A)}$	8.60±0.89$^{a(A)}$	87.20±1.30$^{a(ab)}$	6.80±0.84$^{b(b)}$
	Neem	10.00±0.00$^{a(A)}$	9.60±0.55$^{a(A)}$	9.00±0.71$^{a(A)}$	8.20±0.45$^{a(A)}$
	Nutmeg	10.00±0.00$^{a(A)}$	4.20±1.10$^{b(B)}$	1.00±0.71$^{b©}$	0.00±0.00$^{c(D)}$
	Clove	10.00±0.00$^{a(A)}$	2.40±0.89$^{c(B)}$	1. 00±0.71$^{b(B)}$	0.60±0.00$^{c©}$
	Castor	10.00±0.00$^{a(A)}$	9.20±0.45$^{a(AB)}$	8. 8.60±0.55$^{a(B)}$	8.40±0.89$^{a(B)}$
	Lemongrass	10.00±0.00$^{a(A)}$	8.80±0.45$^{a(B)}$	8.60±0.55$^{a(B)}$	7.52±0.67$^{a(B)}$
0.6	Mentha	8.80±0.45$^{a(A)}$	6.80±1.30$^{b(B)}$	5.80±1.79$^{b(BC)}$	4.80±1.30$^{b©}$
	Neem	9.20±0.45$^{a(A}$	8.60±0.55$^{a(AB)}$	7.80±0.45$^{a(B)}$	7.00±0.71$^{a(B)}$
	Nutmeg	10.00±0.00$^{a(A)}$	3.00±1.22$^{c(B)}$	0.80±0.45c©	0.00±0.00$^{c(D)}$
	Clove	9.40±0.55$^{a(A)}$	1.60±0.55$^{d(B)}$	0.60±0.45$^{c(B)}$	0.00±0.00$^{c(D)}$
	Castor	9.40±0.55$^{a(A)}$	8.80±0.45$^{a(B)}$	7.80±0.45$^{a(A)}$	7.80±0.45$^{a(B)}$
	Lemongrass	10.00±0.00^{a}	8.60±0.55^{a}	7.60±0.55^{a}	7.20±1.10^{a}
0.9	Mentha	8.80±0.45$^{a(A)}$	5.80±1.79$^{b(BC)}$	4.00±1.58$^{c(BC)}$	3.00±1.00$^{c©}$
	Neem	9.20±0.45$^{a(A)}$	8.00±0.71$^{a(B)}$	7.20±0.45$^{ab(BC)}$	7.20±0.45$^{ab(BC)}$
	Nutmeg	10.00±0.00$^{a(A)}$	0.00±0.00$^{d(B)}$	0.00±0.00$^{d(B)}$	0.00±0.00$^{d(B)}$
	Clove	8.80±0.45$^{a(A)}$	0.60±0.45$^{c(B)}$	0.00±0.00$^{d©}$	0.00±0.00$^{d©}$
	Castor	8.80±0.45$^{a(A)}$	7.80±0.45$^{a(A)}$	7.80±0.45$^{a(A)}$	7.60±0.55$^{a(A)}$
	Lemongrass	10.00±0.00$^{a(A)}$	7.80±0.45$^{a(B)}$	6.60±0.55$^{b©}$	5.40±0.55$^{b(D)}$
	F(age)	1.16NS	27.30**	38.47**	33.42**
	F(Duration)	1.40NS	6.04**	3.59*	2.22NS
	F(Oil x Duration)	0.44NS	0.42NS	0.65NS	0.68NS

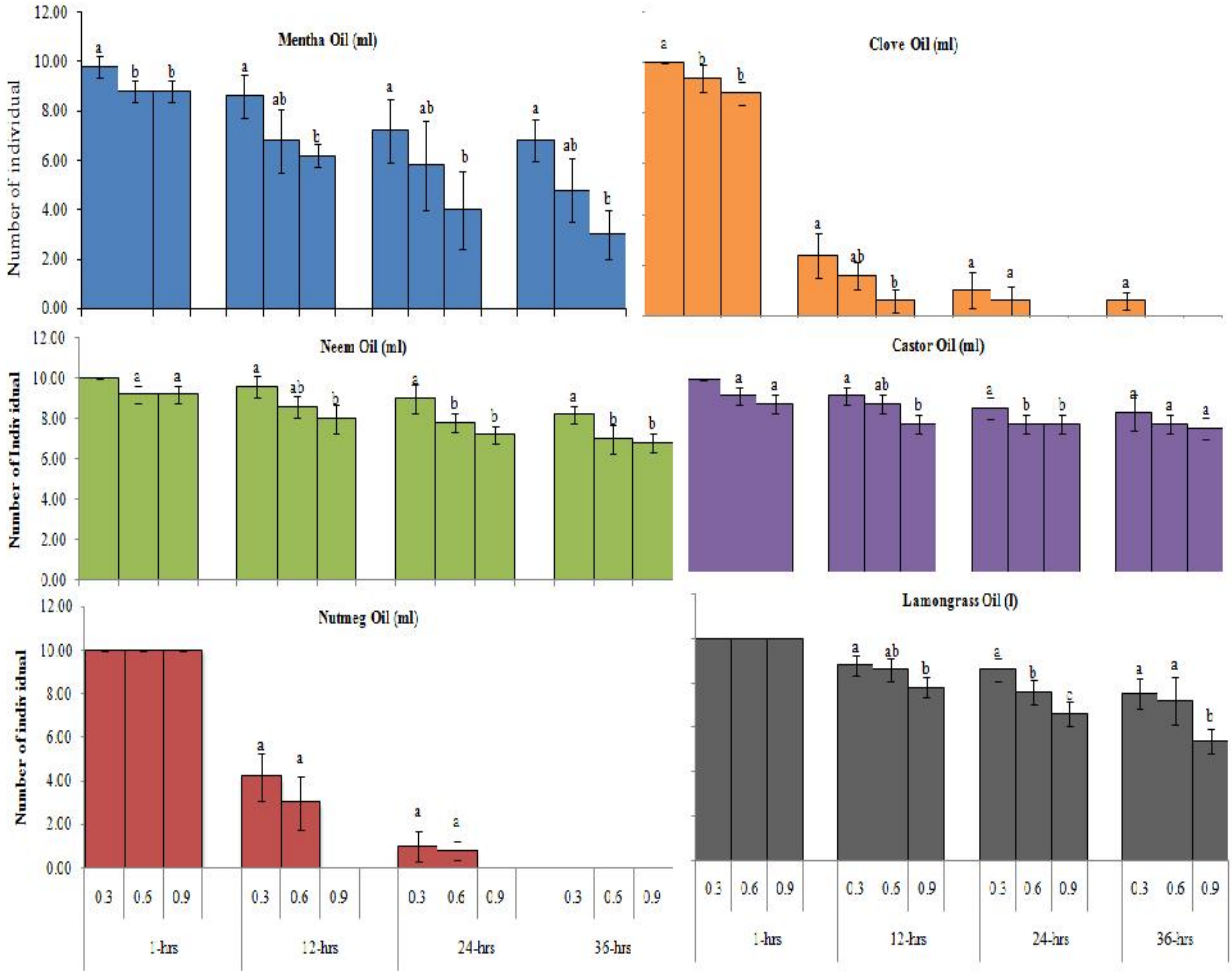

Figure -1: Effect of various concentration (0.3,0.6,0.9) of diriment oils with different time interval (1,12,24 &36 –Hrs) on survival of *Periplaneta americana*

It was also observed that the survivability of adult of *P. americana* was significantly affected by both number of oil and its concentration and there was no interaction between these two factors (Table-2). At 1-hrs, the survivability does not significantly decreased were recorded between oils number and its concentration. While in case of 12, 24 and 36-hrs, the numbers of individual decreased statistically significant differences were recorded between oils and oil concentration (Table-2).

Table-2: Two way ANOVA value in between oils and exposed duration and its interaction.

Value	0.3 ml	0.6 ml	0.9 ml
F (oils)	(F=37,53; P=0.000; df=2, 239).	(F=27.78; P=0.000; df=2, 239).	(F=28.37; P=0.000; df=2, 239).
F (exposed duration)	(F=31.72; P=0.000; df=3.239).	(F=33.30; P=0.000; df=3.239).	(F=36.58; P=0.000; df=3.239).
F (Oil x Exposed duration)	F=4.72; P=0.000; df=3.239).	F=3.72; P=0.000; df=3.239).	F=3.54; P=0.000; df=3.239).

In the present study, the survivability of adult cockroach decreased with increased in oil concentration and exposed duration. The survivability also great affected by of nature of essential oils. The degree of mortality displayed was oil concentration, and exposed duration dependent. The highest mortality was reported in the presence of Nutmeg and clove oil and least for Castor oils Neem and Mentha. In the treatment where types of oil were present, it was found that the pattern of exposed duration had a significant effect with inhibiting the adult survivability.

The adult of cockroach survivability was decrease with nature of oils. Such dramatic inhibition of survival may be due to the different chemical composition. Previous study also reported the mortality in insect directly related to nature of oil (3;8;9). Few studies report that essentials oils have insecticidal activity against cockroach species (3; 7; 25). The oil of lemongrass is well known as powerful and strong insect repellent, used in aromatherapy and perfumery. The eucalyptus oil is a complex mixture of a variety of sesquiterpenes. Fumigant toxicity of essential oils and their constituents has been reported for various insects including cockroaches, house flies, etc (22).

The adult survival was inhibited with increased the exposed duration at all essential oils, various study also reported the increasing the exposed duration was decreasing the survivability of insects. For example, the contact and repellent Toxicity test of *Eucalypltus citriodora*, *Mentha arve*nsis and *Cymbopogen citratus* against *P. americana*. *C. citratus* exhibited the maximum toxicity and repellency with 20% to 100% toxicity between 2 to 24 h time intervals (20). In another study, the *Citrus hystrix* and *Neostylopyga rhombifolia* exhibited 100 % and 87.5% repellency effect against *P. americana* and *Blatella germanica* under laboratory conditions. The essential oil caused an 86% reduction in cockroaches with a residual effect lasting a week after treatment in the field (35). The above results are also similar to toxicity values of oregano oil that continued for at least a week or even 10 days after treatment Although many plant essential oils are reported to have insecticidal or fumigant activity against insect pests (15; 16; 8; 24;31), control of cockroach species has mostly depended on synthetic insecticides (30; 1).

Thus, the present study indicates that the presence of essential oil have an inhibitory effect of survivability of adults cockroach. Of all the experimental oil, Nutmeg oil most responsive to both the oil concentration and exposed duration. Our results further provide to our hypothesis that nature of oil are likely to be more survival deterrent. However, Survival deterrent appears to be concentration dependent. Further studies are therefore required to help identify the specific factors involved in this process.

Conclusion

As previously described that *P.americana* is a common deteriorating pest for museums, libraries, houses etc. To control this pest different chemical control method was applied but now days those methods are banned due to its carcinogenic side effects. That's why the author introduced some natural products oil to determine the toxicity against *P.americana.* These natural product oil are safe and ecofriendly. The author used six essential oils Mentha, Neem, Castor, Lemongrass, Nutmeg and Clove. In all the six oils Mentha and Neem showed lowest survivability of *P.americana* and Lemongrass, Neem, Castor and Mentha.

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