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Comparative bioefficacy of selected plant extracts and some commercial biopesticides against important household pest, *Periplaneta americana*

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Abstract
Owing to the fact that application of chemical insecticides cause adverse effect on beneficial organisms, pollute the environment and are detrimental for human health, plant based products are being tested for the control of variety of insect pests. With this backdrop of knowledge, the present study was carried out to test and compare the bioefficacy of some botanicals with those of commercially available biopesticides against *Periplaneta americana*. Antifeedant activity and toxicity of commercial formulations of Anosom®, Derisom®, Margosom® and ethanolic extract of *Argemone mexicana*, *Nerium oleander*, *Parthenium hysterophorus* were evaluated. Antifeedancy was assessed by taking the weight at pre and post treatment and percent starvation was calculated. Derisom exhibited 83.24% starvation whereas the least percent starvation recorded in *A. mexicana* (51.84%) at the highest concentrations after 24 hrs of treatment. The LC_{50} values of Anosom, Derisom, Margosom, *A. mexicana*, *N. oleander* and *P. hysterophorus* was found to be 0.038%, 0.022%, 0.031%, 6.12%, 4.85% and 4.54% respectively. Based upon the present experiment, plant extracts have efficacy comparable to that of commercial biopesticides currently in use and thus they have the potential for development as commercial insecticides.

Keywords: *P. americana*, Biopesticides, *Argemone mexicana*, *Nerium oleander*, *Parthenium hysterophorus*, LC_{50}, Antifeedant activity

1. Introduction

Cockroaches belong to the order Blattodea and among them best-known pest species is American cockroach, *Periplaneta americana* which is about 30 mm (1.2 in) long. *P. americana* is noted household urban pest found in places such as homes and shops [16]. They feed on human and pet food and can leave an offensive odor [6]. They can also passively transport microbes on their body surfaces including those that are potentially dangerous to humans, particularly in environments such as hospitals [7]. Cockroaches are linked with allergic reactions in humans [5]. One of the proteins that triggers allergic reactions is tropomyosin [23]. These allergens are also linked with asthma [13].

During the past few decades, chemical preparations or synthetic insecticides have been playing dominant role in pest control. Moreover, botanical insecticides, i.e., pest management products based on plant material, plant extracts, or natural products derived from plants, have been touted as potential alternatives to conventional synthetic insecticides, presumably because the natural products would have lesser environmental and human health impacts than many of the older conventional pesticides that have had demonstrable adverse effects on non-target organisms and ecosystems [12]. In the last two decades, considerable efforts have been directed at screening plants in order to develop new botanical insecticides as alternatives to the existing insecticides. Research using plant extracts for controlling cockroaches is limited. Recently, the toxicity and bioefficacy of extract of *Cassia fistula, Datura alba* and commercial product neemarin (0.15% EC) was reported against adult *P. americana* [14, 15]. The essential oil of catnip (*Nepeta cataria* L.) showed repellency against adult male *Blattella germanica* (L.) [20]. The study on seven commercial essential oils for repellency against cockroaches was done and it was found that *Citrus hystix* exhibited complete repellency against *P. americana* and *B. germanica* [27]. Eight essential oils of Chinese medicinal herbs were analysed and among those *Cyperus rotundus*, *Eucalyptus robusta*, and *Ocimum basilicum* had strong repellent activity against the German cockroaches [17]. Thus, in spite of the hundreds of research reports on the effects of plant extracts to pest insects in the laboratory published, only two new botanical insecticides have been commercialized in the past 15 years [11]. These are the neem-based products, with the limonoid azadirachtin as their active ingredient [24], and those based on plant essential oils [10]. With this background, we propose to study the comparative efficacy of soxhlet extracted plant-products and commercial formulations of biopesticides on *P. americana* in an eco-friendly manner.

2. Materials and Methods

2.1 Test insect

Cockroaches were collected from dark, damp places like drains and the required species i.e., *P. americana* was identified [4] and separated. They were then reared in captivity on diet bread crumbs and some cellulose containing materials like rough paper. After continued rearing for 1-2 weeks the adult cockroaches were separated out and used for the desired experiment.

The present experiment is a part of my PhD work which was conducted during 2010-2015 under UGC-MANF (SRF) scheme.

2.2 Biopesticides used

The experimental biopesticides, Margosom® 0.3%EC (3000 ppm), Derisom® 2%EC (20,000 ppm) and Anosom® 1%EC (10,000 ppm) are commercial formulations of botanical extracts obtained from Agri Life, SOM Phytopharma (India) Limited, Bollaram, MedakDist. Hyderabad-AP, India.

Table 1: List of the commercial biopesticides used:

Biopesticides	Common name	Botanical name	Active ingredient	Family
Margosom®	Neem	*Azadirachta indica*	Azadirachtin	Meliaceae
Derisom®	Pongom	*Pongamia glabra*	Karanjin	Fabaceae
Anosom®	Custard apple	*Annona squamosa*	Squamocin (Annonin)	Annonaceae

Besides the above listed commercial biopesticides, ethanolic leaf extraction of *Argemone Mexicana, Nerium oleander* and *Parthenium hysterophorus* were performed in the laboratory using Soxhlet extraction apparatus.

Table 2: List of the plants used:

Plant common name	Botanical name	Tissue used	Family
Indian oleander	*Nerium oleander*	Leaves	Apocynaceae
Carrot grass	*Parthenium hysterophorus*	Leaves	Asteraceae
Prickly poppy	*Argemone mexicana*	Leaves	Papaveraceae

2.3 Preparation of plant extract

The plant materials were collected in and around the campus of AMU, Aligarh. The leaves were thoroughly washed with tap water and shade dried under room temperature (28.0˚C±2˚C). After complete drying the plant materials were pulverized using electrical blender. The powdered materials (50 g) were then put into the thimble of the Soxhlet and extractions were carried out with ethanol (200 ml, Merck) until exhaustion (48 hrs) and filtered through Whatman's No. 1 filter paper. The obtained extracts were concentrated in water-bath at 60 ºC and the residue obtained called as crude extract was stored at 4 ºC as stock solution.

2.4 Preparations of different concentrations of the Biopesticides used

Five concentrations each of Anosom (An), Derisom (De) and Margosom (Ma) *viz.* 0.1%, 0.075%, 0.05%, 0.025% and 0.01% were prepared from the stock solutions in desired solvents (distilled water) by volume/volume dilution.

Similarly, five concentrations each of leaf extract of *A. mexicana* (Ar), *N. oleander* (Ne) and *P. hysterophorus* (Pa) viz. 10.0%, 7.5%, 5.0%, 2.5% and 1.0% were prepared from the stock solutions in desired solvents (distilled water) by volume/volume dilution.

2.5 Feeding bioassay

1 ml of each concentrations of An, De, Ma (0.1%, 0.075%, 0.05%, 0.025% & 0.01%) and leaf extract of Ar, Ne, Pa (10.0%, 7.5%, 5.0%, 2.5% & 1.0%) were sprayed on the bread crumbs of 1cm^2 with the help of pipette. The treated bread crumbs were then mashed properly so as to prepare pellet baits and individually fed to starved cockroaches. The control and positive control (P control) was also run beside these samples. In control only water was used whereas in P control Hit Anti-roach gel was mixed to prepare the pellet baits.

2.6 Antifeedant assay

Pellet baits of different concentrations were prepared and all the above mentioned biopesticides was tested for their antifeedant activity. The control bait and P control was also prepared and place in petridishes. Five replicates for each treatment and 10 adult cockroaches for each replicate were used. The adults to be used for antifeedant assay were left unfed for around 48 hrs, the individual petridishes of starved cockroaches were kept in freezer for few minutes to inactive the cockroaches and their weight were recorded. The cockroaches were fed on the treated baits along with both the controls and reweighted after 24 hours.

Percentage of starvation was calculated according to the formula by Moustafa and Abdel- Mageedd *et al.* [18, 1]

$$\% \text{ Starvation} = (C-E)/(C-S) \times 100$$

Where:

C = Mean weight gain of control larvae within 24 hours

E = Mean weight gain of treated larvae at each tested concentration within 24 hours

S = Mean weight gain of starved control larvae within 24 hours

2.7 Statistical Analysis

The mortality was corrected using Schneider-Orelli's formula [21] and LC_{50} values were determined by probit analysis [8]. Mortality data were expressed as Means±SE and data were submitted to analysis of variance (one way ANOVA) and differences between treatments were compared using t-test. All statistical analysis was performed using the software GraphPad Prism 5.0 and the graphs were produced accordingly.

3. Results

3.1 Antifeedant Assay

The antifeedant activity of biopesticides was assessed on the basis of percent starvation of adult of *P. americana*. Figure 1. shows the percent starvation of Anosom, Derisom and Margosom at 0.01%, 0.05% and 0.025% along with P control after 24 hrs of treatment. Among the commercial formulations, highest concentration i.e. 0.1% of Derisom exhibited maximum percent starvation (83.24%) whereas its lowest concentration (0.01%) also showed fairly higher rate of antifeedacy which is (74.18%). Likewise, Anosom and Margosom at different concentrations showed moderate rate of antifeedant activity (53.13% and 65.43% at 0.1% concentration, respectively).

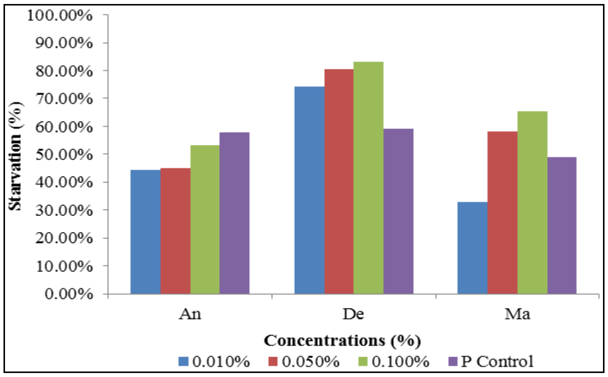

Fig 1: Starvation (%) of commercial formulations of different biopesticides against *P. americana* at various concentrations after 24 hrs of treatment.

Percent starvation of plant extracts of *A. mexicana*, *N. oleander* and *P. hysterophorus* were also evaluated after 24 hrs of treatment (Fig 2). The maximum starvation of 71.93% was noted at 10.0% *N. oleander* extract followed by *P. hysterophorus* (60.58%) and *A. mexicana* (51.84%) at the same concentration. The middle and lower concentrations (5.0% and 1.0%) of the plant extracts also showed significant rate of antifeedant activity which is depicted in Figure 2. Higher percent starvation indicate decreased rate of feeding and hence increase in antifeedant activity.

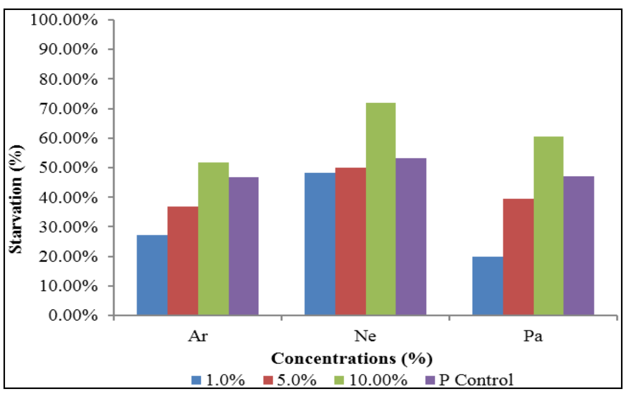

Fig 2: Starvation (%) of different biopesticides against *P. americana* at various concentrations after 24 hrs of treatment.

3.2 Mortality and Toxicity Bioassay

In the present investigation, the toxicity of commercial biopesticides as well as soxhlet extracted ethanolic leaf extracts were tested against the adult of American cockroach. Derisom resulted in 71% of corrected mortality at 0.1% concentration followed by Margosom (61%) and Anosom (58.59%) after 24 hrs of treatment (Fig 3) whereas the highest percent corrected mortality was found in plant extract of *N. oleander* (51.52%) followed by *A. mexicana* (50.51%) and *P. hysterophorus* (48%) at 10% (Fig 4). Furthermore, after 48 hrs of treatment Derisom exceeded in causing more than 90% of the corrected mortality (93.88%) followed by *N. oleander* (86.73%), Margosom (84.85%), Anosom (83.51%), *A. Mexicana* and least by *P. hysterophorus* (73.47%) at the highest concentration (Fig 5-6). The lines of regression of *A. mexicana* and *N. oleander* overlap with each other (Fig 4). Linear regression for percent corrected mortality (Fig 3-6) clearly revealed that all of the tested biopesticides exhibited concentration dependent activity against *P. americana* after 24 and 48 hrs of treatment.

The toxicity of commercial biopesticides Anosom, Derisom and Margosom and extracts of *A. mexicana*, *N. oleander* and *P. hysterophorus* at different concentrations were tested against the adult of *P. americana* after 48 hrs (Table 3 and Table 4). Mean±SE data were recorded and LC_{50} as well as t-test values were calculated. The LC_{50} values of Anosom, Derisom and Margosom were found to be 0.038%, 0.022% and 0.031% respectively. In case of plant extracts, the LC_{50} values of *N. oleander*, *P. hysterophorus* and *A. mexicana* was calculated to be 4.85%, 4.54% and 6.12% respectively. The t-test values and 95% lower and upper confidence limit were significant at P<0.05% level. The mortality values at different concentrations along with P control were significantly greater than that of control.

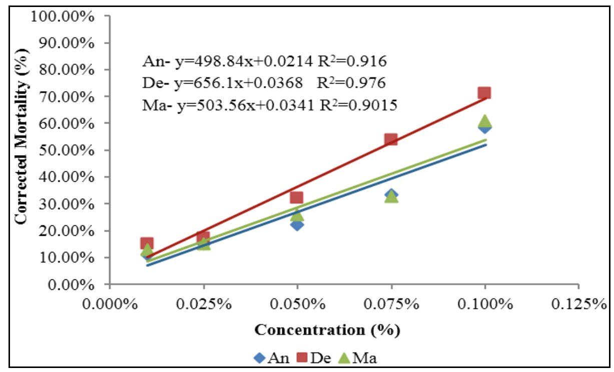

Fig 3: Corrected mortality (%) of commercial formulations of different biopesticides against *P. americana* at various concentrations after 24 hrs of treatment.

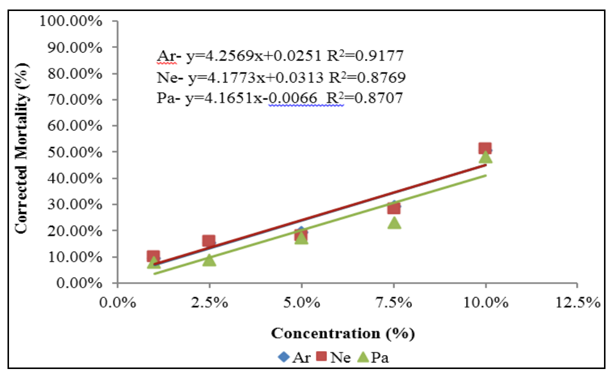

Fig 4: Corrected mortality (%) of different biopesticides against *P. americana* at various concentrations after 24 hrs of treatment.

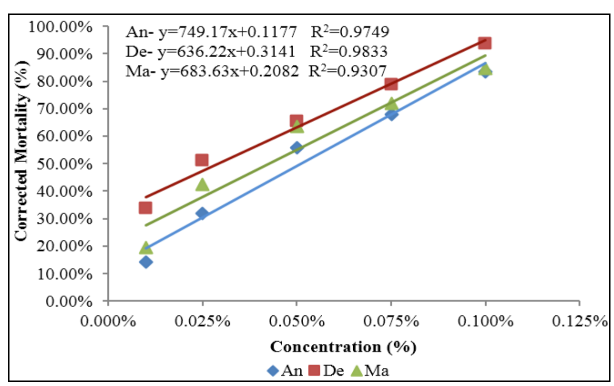

Fig 5: Corrected mortality (%) of commercial formulations of different biopesticides against *P. americana* at various concentrations after 48 hrs of treatment.

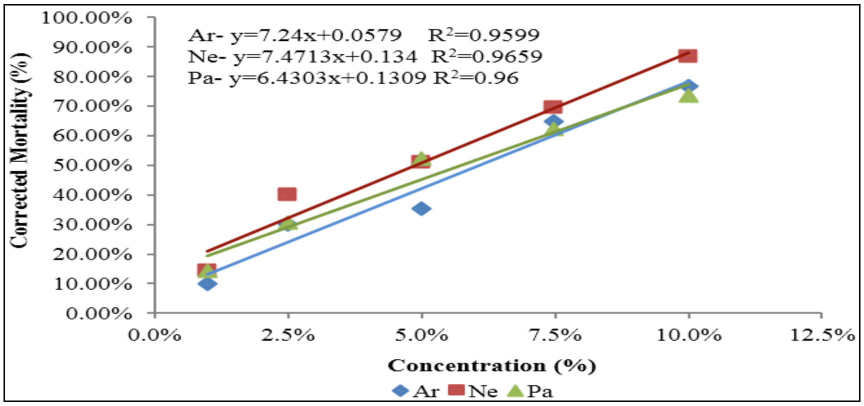

Fig 6: Corrected mortality (%) of different biopesticides against *P. americana* at various concentrations after 48 hrs of treatment.

Table 3: Mortality and toxicity of commercial formulations of different biopesticides against *P. americana* at various concentrations after 48 hrs of treatment.

Biopesticides	Conc. (%)	Mortality (Mean±SE)	LC_{50} (%)	t (df)	95% Confidence limit		Variance
					Lower	Upper	
Anosom	Control	0.6±0.244	0.038%				87.04
	0.010%	3.4±0.400		5.715(4)	2.289	4.511	
	0.025%	6.8±1.241		5.568(4)	3.355	10.25	
	0.050%	11.4±0.748		12.55(4)	9.322	13.48	
	0.075%	13.8±0.860		12.36(4)	11.41	16.19	
	0.100%	17.0±0.632		20.19(4)	15.24	18.76	
	P control	19.0±0.632		30.67(4)	17.24	20.76	
Derisom	Control	0.4±0.244	0.022%				95.26
	0.010%	7.0±0.836		8.820(4)	4.677	9.323	
	0.025%	10.4±0.509		14.14(4)	8.894	11.82	
	0.050%	13.2±0.860		13.20(4)	10.81	15.59	
	0.075%	15.8±0.860		14.96(4)	13.41	18.19	
	0.100%	18.8±0.734		21.11(4)	16.76	20.84	
	P control	19.2±0.583		38.38(4)	17.58	20.82	
Margosom	Control	0.2±0.200	0.031%				112.9
	0.010%	4.0±0.707		4.750(4)	2.037	5.963	
	0.025%	8.6±0.748		10.34(4)	6.522	10.68	
	0.050%	12.8±0.800		18.58(4)	10.58	15.02	
	0.075%	14.4±0.927		14.65(4)	11.38	16.97	
	0.100%	17.0±0.547		28.81(4)	15.48	18.52	
	P control	19.6±0.400		32.33(4)	18.49	20.71	

LC_{50}= lethal concentration that kill 50% of the treated insects; 100 insects (5 replicates of 20 each) were treated at each concentration; * Significant at P<0.05%.

Table 4: Mortality and toxicity of different biopesticides against *P. americana* at various concentrations after 48 hrs of treatment.

Biopesticides	Conc. (%)	Mortality (Mean±SE)	LC_{50} (%)	t (df)	95% Confidence limit		Variance
					Lower	Upper	
A. mexicana	Control	0.2±0.200	6.12%				155.5
	1.0%	2.2±0.374		4.472(4)	1.161	3.239	
	2.5%	6.2±0.663		8.485(4)	4.358	8.042	
	5.0%	7.2±1.114		5.715(4)	4.108	10.29	
	7.5%	13.0±0.316		34.21(4)	12.12	13.88	
	10.0%	15.4±0.509		31.03(4)	13.98	16.82	
	P control	19.6±0.244		48.50(4)	18.92	20.28	
N. oleander	Control	0.4±0.244	4.85%				96.57
	1.0%	3.2±0.583		3.810(4)	1.581	4.819	
	2.5%	8.2±0.969		8.045(4)	5.508	10.89	
	5.0%	10.4±0.927		9.129(4)	7.825	12.97	
	7.5%	14.0±0.836		13.21(4)	11.68	16.32	
	10.0%	17.4±0.748		20.32(4)	15.32	19.48	
	P control	19.4±0.400		34.69(4)	18.29	20.51	
P. hysterophorus	Control	0.4±0.244	4.54%				88.92
	1.0%	3.2±0.374		4.802(4)	2.161	4.239	
	2.5%	6.4±0.678		9.487(4)	4.517	8.283	
	5.0%	10.6±0.979		10.52(4)	7.880	13.32	
	7.5%	12.6±0.871		15.25(4)	10.18	15.02	
	10.0%	14.8±1.020		11.53(4)	11.97	17.63	
	P control	19.6±0.400		51.31(4)	18.49	20.71	

LC_{50}= lethal concentration that kill 50% of the treated insects; 100 insects (5 replicates of 20 each) were treated at each concentration; * Significant at P<0.05%.

4. Discussion
Plants are rich source of bioactive compounds that can be used as a suitable substitute to develop eco-friendly pest management strategies. In the present study, screening of the plant extracts along with the commercial botanicals showed that both possess bioactivity against *P. americana*. From the results obtained, all the three plant extracts *viz.*, *A. mexicana*, *N. oleander*, *P. hysterophorus* and commercial formulations of biopesticides *viz.*, Anosom, Derisom and Margosom exhibited viable percent starvation/antifeedant activity. These botanicals induced reduced feeding when compared to that of control. Our results are comparable to those of other scientists who worked on the same plant extracts against cockroaches as well as other pest insects [3, 17, 19, 22]. It was reported that the extract of *N. oleander* was highly effective on the nymph of American cockroaches at different concentrations [9]. Individual and joint toxicity of botanical and microbial pesticides *viz.*, Anosom®, Derisom®, Margosom®, Lipel® MVP II and XenTari® against diamondback moth, *Plutella xylostella* were also investigated [26]. Achio *et al.* [2] found that there was a direct relation between the concentration and degree of lethal effectiveness of the neem seed oil which contains azadirachtin as an active ingredient which is in accordance with the present findings. Besides the plant extracts investigated in the present study, other plant-based products also showed similar results against *P. americana*. Essential oils from *Citrus hystrix*, *Cymbopogon citratus*, *Mentha aruensis* and *Eucalyptus* spp. showed repellency against American cockroach under laboratory conditions [25]. Currently, cockroach control is most dependent upon synthetic insecticides which cause ecological disruption and development of resistance. Therefore, there is a need to explore, develop and commercialize newer potential insect management products with a minimum environmental impact.

5. Conclusion
From the present study, it can be concluded that plant extracts have high prospective to put back the indiscriminate use of synthetic harmful insecticides in saving the environment. Based on the comparable bioefficacy of soxhlet extracted plant products and commercial formulations of biopesticides they have potential for development as commercial insecticides with broad-spectrum activity and lesser adverse effects on human health and the ecosystem.

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