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Effect of some plant extracts against the ant *Paratrechina longicornis* under laboratory conditions

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Abstract
An investigation was carried out to evaluate the ingestion toxicity of some plant extracts of nine different species, belonging to seven families against workers of *Paratrechina longicornis*. Plant species were *Allium sativum*, *Anethum graveolens*, *Calendula officinalis*, *Coriandrum sativum*, *Eucalyptus citriodora*, *Mentha viridis*, *nigella sativa*, *Rosmarinus officinalis*, and *Trigonella foenum-graecum*. It was found that *E. citriodora* was the most potent one towards workers followed with *A. graveolens*, then *M. viridis*, *N. sativa*, *T. foenum-graecum*, *R. officinalis*, *C. officinalis*, *A. sativum*, and *C. sativum*, respectively. Mortality depends mainly upon the type of plant species as well as the increase of the plant extract concentration and the increase of the time of exposure. *Eucalyptus citriodora* was the most potent plant, recording the lowest LC_{50} and LC_{90} which were 33.1% and 74.1%, respectively. On the other hand, *C. sativum* showed the least toxicity as the dose of LC_{50} and LC_{90} recorded 371.5% and 3801.9%, respectively. The longest average survival period (S50) occurred with *A. sativum* and *C. sativum* recording 10 days for each, whereas the shortest one recorded 3 days with *E. citriodora*, compared to 22 days for control.

Keywords: Ingestion toxicity, LC_{50}, LC_{90}, survival periods

Introduction
Paratrechina longicornis is the most dispersed of ant species and is commonly known as the longhorn crazy ant [1]. The ant is found predominantly in warmer regions of the tropics and subtropics. The known habitats of the ant are diverse, having a wide range of distribution, which nesting in moist soil under rocks beside palm trees and on dry soil containing leaf litters rich with sheep and goat faeces as well as under rocks in moist, compacted clay soil and on twigs of small shrubs [2]. It exhibits typical characteristics of tramp species as polygyny, unicoloniality and colony budding [3]. These traits aiding its success as an invasive species. The ant is not aggressive but it has the ability to disturb local ecosystem leading to destruction of indigenous ant species [4]. Economic and ecological harm can caused by some of these invasive traits [5, 6] as the ant can be a significant agricultural pest as it helps in the distribution and/or protection of some Hemipteran insects such as mealy bugs, scale insects, and plant lice [1]. The environmental threats caused by the use of synthetic insecticides for pest insect management induce researchers to seek for safe alternatives as botanical insecticides [7, 8] as they have confirmed to be effective, safe, cheap, and easy to process and apply for farmer in poor countries [9,10]. Horizontal dissemination of toxicants in social insects as ants, bees, some wasps and termites is occurred by trophallaxis when nutrients are orally transmitted between individuals [11] and it is the primary means of transferring toxicants in baits against ants and termites [12]. Many researchers used individuals ants housed in Perti dishes to test effect of plant extracts on ant species using ingestion, contact or repellency method [13-18]. So, in the present study, we report on a laboratory study on the toxic effect of nine common species *Allium sativum*, *Anethum graveolens*, *Calendula officinalis*, *Coriandrum sativum*, *Eucalyptus citriodora*, *Mentha viridis*, *Nigella sativa*, *Rosmarinus officinalis*, and *Trigonella foenum-graecum* plant extract against the pest under study.

Materials and Methods
Paratrechina longicornis nest was collected from the west bank of the river Nile facing to El-Minia Governorate building. The nest had few queens, several hundreds of workers and broods. To maintain the nest, the method of Ali & Mashaly [19] was followed.

In this case the soil containing the ant nest was poured into a plastic bowl and left for few days to dry. At the same time few drops of water were poured at a fixed region on the soil on the soil to attract ants to the moistened region. The dried soil on the other side was removed every other day. The remaining moist soil with ants were removed and moved into a plastic bottle. A hole was made at the lower side of the bottle to serve as an exit and entrance for workers. The bottle was placed inside a plastic bowl with 25 cm internal diameter and 60 cm vertical wall to serve as a foraging area. The inside wall was coated with petroleum jelly to prevent ants from escaping. The ants were fed tiny drops of honey placed on a sheet of paper, in addition to fresh dead insects. Also 10% sugared water in a glass tube plugged with a piece of cotton was offered.

Source of plants

Nine species of Egyptian plants (Table 1) were selected for the present investigation. Plant species namely *Anethum graveolens* L., *Eucalyptus citriodora* Hook., *Mentha viridis* L., *Rosmarinus officinalis* L., *Allium sativum* L., *Calendula officinalis* L., *Coriandrum sativum* L., *Nigella sativa* L., and *Trigonella foenum-graecum* were collected from the Faculty of Agriculture farm, Minya University.

Table 1: Family, species, common name, part of plant, mass of dry material (Mat.), mass of extract (Ext.), and yield of plant species and extract used in bioassay with *P. longicornis* (Hymenoptera: Formicidae) workers.

Family	species	Common name	Part of plant	Mat.(g)	Ext.(g)	Yield (%)
Apiaceae	*Anethum graveolens* L.	Dill	Seeds	50	13.14	26.3
	Coriandrum sativum L.	Coriander	Seeds	50	5.59	11
Composite	*Calendula officinalis* L.	Pot marigold	Flowers	50	4.99	10
Fabaceae	*Trigonella foenum-graecum L.*	Fenugree	Seeds	50	7.79	15.6
Liliaceae	*Mentha viridis L.*	Spearmint	Leaves	50	5.82	11.7
	Rosmarinus officinlis L.	Rosemary	Leaves	50	7.28	14.6
Alliaceae	*Allium sativum* L.	Garlic	Bulbs	200	21.8	10.9
Myrtaceae	*Eucalyptus citriodora* Hook	lemon scented gum	Leaves	50	10.05	20
Ranumculaceae	*Nigella sativa* L	Black cumin	Seeds	50	14.3	28.6

Yield % = (dried weight of the produced methanol extract / dried weight of powdered test plant) x 100.

Plant Extracts Preparation

Except *Allium sativum* plant, each plant species was washed under a running water for 20 min., then left for 7 days to dry under room conditions, weighed several times to get a constant weight to ensure the plant dryness, then finely powdered using an electric blender. A sample of 50 g of powder of each plant species was macerated with 300ml. of methanol (90%) at room temperature for two days and filtered using double ring filter papers. In case of *A. sativum* plant, fresh bulbs were chopped into slices (200 g) in an electric blender then the yield was macerated with 9oo ml of 95% methanol at room temperature for 1 day. The maceration method repeated once again for each of the candidate plant extract then the combined filtrate of each extract was concentrated to dryness by rotary evaporation (Büch rotary evaporator) at 40 ºC. The yield of each methanolic extract was weighed using an electric balancer (Analytical Balance, Model 205A, and Switzerland).

Bioassays

To determine which concentration of each plant species is required to kill 50% and 90% of workers of *P. longicornis*, 100 individuals were randomly picked up from the nest and each 10 individuals with three replicates for each concentration (nine plant extracts plus control) were put into a Petri dish lined with a moistened filter paper. Ten ml of each tested plant extract were taken first as stock solution which was considered as 100% concentration and from it, four different concentrations were prepared as follows: 25% (1ml stock solution + 3ml 10% sugar solution), 50% (2ml stock solution + 2 ml 10% sugar solution), 75% (3 ml stock solution + 1ml 10% sugar solution) and 100% (4ml stock solution alone) V/V. During bioassays workers were provided every day with 50µl of each concentration, placed on a microscope slide in the center of the plastic Petri dish. The workers were provided water only for 24 h. prior to the test. Each concentration was added with a micro-syringe through a tiny hole made in the lid without removing the lid in order to avoid ant disturbance. Daily observation was made for three days to record accumulative mortality. The percentage of mortality was calculated and corrected using Abbott's formula [20]. Percentage of mortality = (Number of dead workers / Number of alive workers) x 100) Corrected percentage of mortality = [(T - C) / (100 – C)] x 100

Where, T = % mortality in test concentration.

C = % mortality in control.

Identification of Test Ant

Few individuals of workers of the ant were preserved in 70% ethyl alcohol in a small specimen tube and sent by post to B. Taylor for identification. The ant was identified as *Paratrechina longicornis* (Latreille)

Statistical Analysis

To detect the toxic effect of the plant extract, statistical analysis of data was done using SPSS (Statistical Package for the Social Science) software. The level of significance was at $p<0.05$. Data of the mortality experiment were analyzed using a one-way ANOVA. The mortality data were corrected with Abbott's formula [20] and analyzed by probit analysis [21] to determine lethal concentration (LC_{50} and LC_{90}) for each concentration.

Results and discussion

The majority of the tested plant extracts proved to have ingestion toxicities against workers of *P. longicornis*. Mortality depends mainly on the type of plant species as well as the increase of plant extract concentration and the increase of the time of exposure. Two plant extracts from the nine tested extracts were proved to be the most toxic ones, *E. citriodora* (lemon scented gum) and *A. graveolens* (dill), respectively, followed with *M. viridis* (spearment), *T. foenum-graecum* (fenugreek), *N. sativa* (black cumin), *C. officinalis* (pot marigold), *A. sativum* (garlic), *R. officinalis* (rosemary) then *C. sativum*, respectively (Table2). However, each of all the tested extracts induced mortality at the four different

concentrations (25%, 50%, 75%, and 100%) when workers were exposed for 72 h, comparing to the control. *Eucalyptus citriodora* caused higher mortalities for workers after the 24 h of exposure at the four concentrations. The same was true with *A. graveolens*. In the case of *M. viridis*, the highest mortalities occurred at the first and the second day when workers treated with 50%, 75%, and 100%. Generally, the mortality of workers occurred when they were exposed to each of the plant extract at the four different concentrations after 72 h of exposure. Indeed, toxicity effects of essential oils and crude plant extracts on some insects have been known from many studies but as the authors are aware, no study has been done on that effect on *P. longicornis* workers, the ant under study. The present results are partially consistent with previous study obtained by Batish et al. [22] who revealed that *E. citriodora* extract possesses a wide spectrum of biological activity including ant-microbial, fungicidal, insecticidal, insect repellent, herbicidal, acaricidal and nematicidal. The insecticidal activity includes, human head lice, biting insects as mosquitoes, stored product insects and house flies. Results obtained by Al-Jabr [23] were in accordance with our results, who indicated that extract of *M. viridis* had an effect against the beetle *Tribolium castaneum*. In this study, the plant, *A. sativum* has a moderate effect but it had a significant effect on increasing the larval and pupal duration as well as pupal weight of the cotton leaf-worm, *Spodoptera littoralis* (Boisd.) and the percentage of hatchability of deposited eggs was significantly decreased [24]. Wagan *et al.* [25] found that *Mentha haplocalyx* and *Allium ascalonicum* had repellency and toxicity effects on larvae and adults of *Sitophilus zeamais*. *R. officinalis* extract has a moderate effect in the ant under study; also Ali *et al.* [26] working with the same plant found that a strong effect on larvae of the carpet beetle *Attagenus fasciatus* which gave 90% and 100% mortality after 28 days of exposure when larvae fed on wool treated at concentration of 1.5mg/cm² and 6mg/cm², respectively. In other studies dealt with the use of botanical extracts against ants, Boulogne *et al*. (17) tested the effect of six plant extracts against the ant *Acromyrmex octospinosus* through repellency, contact and ingestion toxicity. The plant extracts were: soaked solution of fresh crushed seeds of *Mammea americana*, boiled solution of fresh leafs of *Nerium oleander*, water solution of dried leafs of *N. oleander*, boiled solution of *Nicotiana tabacum* dried leafs, water solution of dried leafs of *Trichillia pallida* and boiled solution of dried seeds of *Rollinia mucosa*. They found that the treatment with *M. Americana* seed extract and *N. tabacum* leaf extract had a significant effect on ant survival with *N. Tabacum*, the most efficient, and all of the plant extracts had significant repellent effect with *N. tabacum* decoction was the most repellent one while *M. Americana* was the least effective. On the other hand, only *R. mucosa* seed extract and *T. pallida* leaf extract had no toxicity by ingestion, whereas *M. Americana* seed extract was the most active extract, followed by *N. tabacum* extract, *N. oleander* leaf extracts had the least active effect. Three Saudi plants, harm (*Rhaza stricta*), boxthorn (*Lycium shawii*) and artemisia (*Artemisia inculata*) were tested in a minced bait against workers of samsum ant (*Pachycondyla sennaarensis*); the highest toxicity towards workwers using the plant extracts of boxthorn at a concentration of 0.3 mg per gram of food was 20.30% mortality per day and 100% average death rate of all ants in 4.9 days [27]. Wagan *et al.* [14] stated that essential oil from *Curcuma longa* L. showed a strong repellency to Pharaoh ant (*Monomorium pharaonis*) for up to 4h of observation in the absence and presence of food, whereas oil from *Litsea cubeba* was less repellent than oil from C. longa in the test without food but not in the test with food. Gomes *et al.* [16] investigated toxicity of some plant extracts from Bahia, Brazil to the ant *Atta sexdens* workers and they found that, the leaf and branch extracts of *Zanthoxylum rhoifolium* and that of bark of *Simarouba amar* were the most toxic ones when the workers treated topically, whereas four extracts were toxic and showed delayed action through ingestion. Souza *et al.* [13] tested the topical effect of five leaf fractions of *Esenbckia pumila* on the ants *Atta laevigata* and *acromyrmex balzani* using different solutions of the hexane, ethanolic, dichloromethane, ethyl acetate as well as methanolic extracts and the ethanolic fruit extracts as well. They found that all the fractions extracted showed antcidal effects and the ant *A. laevigata* was more susceptible than *A. balzani*.

Table 2: Percentage of mortality of *Paratrechina longicornis* workers treated with different concentrations of plant extracts for different periods.

Plants	Concentration (V/V %)	24	mortality (%) mean ± SE Hours after treatment 48	72	Total
Allium sativum	25%	0^{a}	0^{a}	6.63 ± 0.33^{ab}	6.63 ± 0.33^{ab}
	50%	2 ± 2.7^{a}	3.3 ± 0.23^{a}	10.33 ± 0.43^{abc}	15.66 ± 3.36^{abcd}
	75%	3.36 ± 0.13^{ab}	13.27 ± 0.53^{abcd}	6.73 ± 2.64^{ab}	23.36 ± 3.3^{bcde}
	100%	6.66 ± 0.33^{ab}	20 ± 0^{bcd}	12 ± 0.57^{abcd}	38.66 ± 0.9^{efgh}
	Control	0^{a}	0^{a}	0^{a}	0^{a}
Anethum graveolens	25%	6.33 ± 0.33^{ab}	19.57 ± 1.97^{bcde}	13.67 ± 2.3^{abcd}	40 ± 0^{efgh}
	50%	26.66 ± 3.3^{de}	20 ± 0^{bcde}	10 ± 0^{abc}	$56.66\pm3.3^{hi\ J}$
	75%	45.22 ± 0.57^{fg}	10 ± 0^{abc}	33.4 ± 1.6^{defg}	88.62 ± 2.17^{JK}
	100%	60 ± 5.2^{g}	32.69 ± 2.2^{efgh}	0^{a}	92.67 ± 5.4^{KL}
	Control	0^{a}	0^{a}	0^{a}	0^{a}
Calendula officinalis	25%	0^{a}	0^{a}	6.66 ± 0.33^{ab}	6.66 ± 0.33^{ab}
	50%	0^{a}	6.66 ± 0.33^{ab}	6.7 ± 0.97^{ab}	13.36 ± 1.3^{abc}
	75%	3.36 ± 0.33^{ab}	13 ± 2.97^{abcd}	10 ± 0^{abc}	26.66 ± 3.3^{cdef}
	100%	10 ± 0^{abc}	13.33 ± 2.6^{abcd}	20 ± 0^{bcde}	43.33 ± 2.6^{fgh}
	Control	0^{a}	0^{a}	0^{a}	0^{a}
Coriandrum sativum	25%	0^{a}	0^{a}	6.63 ± 0.13^{ab}	6.63 ± 0.13^{ab}
	50%	0^{a}	3.33 ± 0.33^{a}	10 ± 0^{abc}	13.33 ± 0.33^{abc}
	75%	0^{a}	16.36 ± 0.33^{abcde}	7.3 ± 2.97^{ab}	23.66 ± 3.3^{bcde}
	100%	0^{a}	16.66 ± 3.6^{abcde}	20 ± 0^{bcde}	36.66 ± 3.6^{efgh}
	Control	0^{a}	0^{a}	0^{a}	0^{a}

Eucalyptus citriodora	25%	918.33±0.33^{bcd}	10±0^{abc}	18 ±2.97^{bcde}	946.33 ±6.27^{ghi}
	50%		20±5.7^{bcde}	12.66±0.33^{abcd}	88.66±6.69^{JK}
	75%	56.0±0.66^{g}	13±3.3^{abcd}		95.77±3.87^{L}
	100%	70±0^{h}	1.1±0.33^{a}	12.11±0.57^{abcd}	7.76±5.63^{L}
		6.66±5.3^{i}	0^{a}	0^{a}	0^{a}
	Control	0^{a}		0^{a}	
Mentha viridis	25%	0^{a}	10 ±0^{abc}	13.33±0.66^{abcd}	23.33±0.66^{bcde}
	50%	6.65±3.3^{ab}	30±0^{defgh}		49.65 ±3.3^{ghi}
	75%	20±0^{cde}	23.66±0.33^{bcdef}	13±0^{abcd}	55.98±0.9$^{hi\ J}$
	100%	33.36±3.3^{ef}	20±0.33^{bcde}	12.32±0.57^{abcd}	66.36±3.6$^{i\ J}$
	Control	0^{a}	0^{a}	13±0^{abcd}0^{a}	0^{a}
Nigella sativa	25%	0^{a}	6.63±0.13^{ab}	0^{a}	6.63±0.13^{ab}13.63±0.33^{abc}
	50%	0^{a}	13.63±0.33^{abcd}	0^{a}	
	75%	13.33±0.66^{abc}	20±2.64^{bcde}	10±1^{abc}	43.33±2.3^{fgh}
	100%	16.36±1.6^{bcd}	26.97±1.7^{cdefg}	13±0^{abcd}	56.33±3.3$^{hi\ J}$
	Control	0^{a}	0^{a}	0^{a}	0^{a}
Rosmarinus officinalis	25%	0^{a}	6.63±0.13^{ab}	6.7±2.17^{ab}	13.33±2.3^{abc}
	50%	0^{a}	6.66±0.33^{ab}	9.97±2.97^{abc}	16.63±3.3^{abcd}
	75%	3.33±0.33^{ab}	20.33±2.97^{bcde}	9.67±0.33^{abc}	33.33 ± 3.6^{defg}
	100%	6.63±0.33^{ab}	23.37±0.66^{bcdef}	6.63±2.3^{ab}	36.63±2.3^{efgh}
	Control	0^{a}	0^{a}	0^{a}	0^{a}
Trigonella foenum graecum	25%	0^{a}	6.63±0.23^{ab}	10±0^{abc}	0^{a}
	50%	0^{a}	10±0^{abc}	16.66±3.3^{abcde}	16.63±0.23^{abcd}
	75%	6.66±3.3^{ab}	20.66±0.57^{bcde}	16.7±0.3^{abcde}	26.66±3.3^{cdef}
	100%	14.66±2.3^{bcd}	20±0^{bcde}	26.33±1.3^{cdef}	44.02±1.6^{fgh}
	Control	0^{a}	0^{a}	0^{a}	60.99 ± 2.7$^{hi\ J}$

Numbers followed by different letters in vertical row are significantly different (P<0.05) S.E. = Standard error of mean.

Data presented in Table 3 reinsure that *E. citriodora* was the most potent one, followed by *A. graveolens* as they recorded the lowest LC_{50} and LC_{90}. The LC_{50} which induced with *E. citriodora* and *A. graveolens* against *P. longicornis*, recorded 43.7% and 33.1% (V/V %), respectively, when workers exposed for the first day and recorded 95% and 46.8% (V/V %), respectively, when workers exposed for the second day. On the other hand, *C. sativum* showed the least activity after the third day of exposure as the LC_{50} and LC_{90} recorded 371.5% and 3801.9% (V/V %), respectively. Huang *et al.* [15] working with the ant *Solenopsis invicta* indicated that the methanol extract of the fern *Pronephrium megacupse* had toxic effects on both macerates and micergates. They found that the LC_{50} values of the methanol extract and ethyl acetate fraction against macergate were 524.0 and 149.9 µg/g, respectively, after 48h of exposure and 362.5 and 99.0 µg/g, respectively, after 72h 0f exposure, while in case of macergate the LC_{50} value were 321 and 90.0 µg/g, respectively, after 48h of exposure and 235.4 and 79.1 µg/g, respectively, after 72h of exposure. Three Thai herbs including tuba root (*Derris eliptica* Bent), yam bean seeds (*Pachyrhizus erosus* L.) and tea seed cake (*Camllia sp*.) were tested against adult workers of the Pharaoh ant (*Monomorium pharaonis* L.) using filter paper method as a contact method [18]. Their results showed that the tuba root, yam seed, and tea seed cake extracts. The average survival period (S50) of *P. longicornis* workers exposed to each of the extracts at the concentration 25% (V/ V%) was 3, 5, 6, 7, 8, 9, 8, 10, and 10 days, for *E. citriodora*, *A. graveolens*, *M. viridis*, *N. sativum*, *C. officinalis*, *R. officinalis*, *T. foenum-graecum*, *A. sativum*, *Sativum*, respectively, comparing to 22 days for control (Tables 4). Nagamoto *et al.* [28], stated that the delayed toxicant occurs when the mortality of ant workers is lower or equal to 15% up to the first day of evaluation and higher or equal to 90% after the twentieth first day of evaluation, accordingly, the current study revealed that *R. officinalis*, *C. officinalis*, *A. sativum*, and *C. sativum* have a delayed toxic action, but *E. citriodora* has for some extent an accelerated action followed with *A. graveolens*, then *M. vridis* and *N. sativa*, respectively. Gomes, *et al.* [16] working with the ant *Atta sexdens* demonstrated that the average survival period in the *Esenbeckia grandiflora* leaf, *Casearia sylvestris* bark, *Zanthoxylum rhoijolium* leaf, and *Zanthoxylum rhoijolium* branch treatments at the concentration of 0.2 mg/ml was 7, 8, 8, and 10 days , respectively, evidencing their mortality after ingesting them.

Table 3: The lethal concentrations (LC_{50} and LC_{90}) of nine plant extracts on *Paratrechina longicornis* workers.

Plant	Lethal concentration % LC_{50} % LC_{90} %(V/V %)	Regression equation
Allium sativum 3rd day	239.9 1513.6	y = 1.6026x + 1.1889
Anethum graveolens 1st day 2nd day 3rd day	95 380	y = 2.1184x + 0.8126
	46.8 195	y = 2.0526x + 1.5789
	34.7 134.9	y = 2.1395x + 1.7142
Calendula officienalis 3rd day	213.8 1288.2	y = 1.6395x + 1.1842
Coriandrum sativum 3rd day	371.5 3801.9	y = 1.2711x + 1.7316
Eucalyptus citriodora 1st day 2nd day	43.7 104.7	y = 3.3816x - 0.5526
	33.1 74.1	y = 3.6737x - 0.5895
Mentha viridis 1st day 2nd day 3rd day	186.2 758.6	y = 2.1132x + 0.1947
	97.7 398.1	y = 2.0974x + 0.8211
	56.2 213.8	y = 2.2289x + 1.0884
Nigella sativa 2nd day 3rd day	147.9 645.7	y = 2.0079x + 0.6368

	109.6 363.1	y = 2.4868x - 0.0747
Rosmarinus Officinalis 3rd day	134.9 562.3	y = 2.0553x + 0.6179
Trigonella foenum graecum 2nd day 3rd day	223.9 1318.3	y = 1.6553x + 1.1179
	112.2 794.3	y = 1.5079x + 1.9068

LC_{50} against adult workers ca. 0.22%, 0.35% and 0.55% w/v after 24 hours exposure, respectively.
LC_{50} represents lethal concentration that cause 50% mortality 0 represents lethal concentration that cause 90% mortality. Session analysis was performed between different concentration of plant extract and response of workers

Table 4: Mortality (%) and average survival period (S50) in days of *Paratrechina longicornis* workers fed on sugar solution mixed with several plant extracts at the concentration of 25%.

Treatment	Accumulative mortality (%) day 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 S50
Allium sativum	0 0 6 20 24 30 33 40 44 50 53 63 67 70 80 90 93 100 10[c]
Anethum graveolens	6 26 40 43 50 53 64 72 84 90 100 5[b]
Calendula officienalis	0 0 6 17 23 30 37 50 53 67 73 80 84 87 90 90 96 100 8[b]
Coriandrum sativum	0 0 6 14 20 24 30 40 43 50 54 63 70 80 90 93 96 100 10[c]
Eucalyptus citriodora	16 26 46 66 80 90 100 3[a]
Mentha viridis	0 10 23 33 44 50 66 70 74 80 90 6[b]
Nigella sativa	0 6 6 23 30 37 50 57 63 70 74 80 84 90 96 100 7[b]
Rosmarinus officinalis	0 6 13 20 27 30 40 55 50 53 62 70 80 84 90 93 96 100 9[bc]
Trigonella foenumgraecum	0 6 16 23 33 40 43 50 54 60 63 70 80 84 90 96 100 8[b]
Control	0 0 0 0 0 0 0 0 0 0 10 10 10 10 10 10 10 20 40 40 40 50 50 60 80 90 93 100 22[d]

Number followed by different letters are significantly different (P<0.05)

Conclusion

It can be concluded that, the toxicity of the crude extract of each of the plant under test has a slow acting effect, therefore, it can be used for ant control as a suitable agent for ant bait as it gives a chance for foraging workers to transport the bait toxicity for brood, nurse workers and queens inside nest.

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