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Laboratory Evaluation of Toxicity of Boric Acid and Borax against American cockroaches (Periplaneta americana L.) in Jeddah Governorate.

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ABSTRACT

Periplaneta americana is an important insect in medicine, and they have been generally known as domestic pest, and they are found in or around homesand buildings. Because their way of living, P. americana has a critical role in transmission of infectious diseasese and known as vector for numerous pathogens. Therefore, a strong require to control this pest with a low coast and non-harmful insecticides to human and the environment. In this study, the natural products of boric acid and borax were evaluated against adults and nymphs of P. americana by feeding and contact toxicity methods after 48h. of exposure. The results showed that borax were more effective than boric acid by LC_{50} and LC_{90} values when used by contact toxicity method against adults than nymphs. The present study revealed that boraxhave great potential for control against adults and nymphs of P. Americana and it can be used as a safety insecticide in Jeddah governorate.
Keywords: Insecticides, boric acid, borax, P. americana, toxicity, nymphs, adults

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INTRODUCTION

American cockroaches (Periplanetaamericana) (Linnaeus), order Dictyoptera, is an important insects in medicine [1] and they have been generally known as domestic pest and they are found in or around homes and buildings [2].Out of 500, only 30 species are considered as household pest [3]. They survive in warm weather with high moisture conditions as well as in unfavorable environments for humans [4]. Because their way of living, P. americana has a critical role in transmission of infectious diseasese and known as vector for numerous pathogens[5].P. americana can spread bacteria, fungi, and other pathogenic microorganisms from infected areas [6], and cause allergies to human [7]. They play important role in the transmission of different diseases by mechanical as well as by biological ways [8]. P. americana spends most of its time in sewage, sewer pipe which usually contains high density of pathogens [9]. Also, they feed on garbage, and they have large opportunities to disseminate human pathogen [10]. In addition, their nocturnal and filthy habits of eating their feces make them ideal carriers of numerous pathogenic microbes [11]. A numerous pathogen such as bacteria, fungi and molds, helminths, protozoans and viruses, harmful to humans being are carried by cockroaches, and they present in their feces [12]. More than 40 pathogenic and non-pathogenic bacterial species have been identified from cockroaches. Such as Actinomycesrandingae, Alcaligenesfaecalis, Arthrobactercumminnsii, Aureubacteriumspp., Bacillus spp.,[13]. Many parasites were isolated from cockroaches e.g., cysts of Entomoebahystolitica, oocysts of Cryptosporidium parvum, Cyclosporacayetanensis [14]. A number of fungal species have been also isolated from both the external body parts as well as fecal of cockroaches such as Candida spp., Rhodotrula spp., Aspergillus spp., Fusarium spp., Penicillin spp. and Geotrichum spp. [15]. Helminths have also been reported in cockroaches collected from different areas [16], included Strongyloidesstercoralis, Ascarislumbricoides, Trichuris trichina and Taniaspp [17]. Protozoa types that were identified from cockroaches included Cyclospora spp., Endolimax nana, Blastocystishominis, Isospora belli, Entamoebahistolytica, Cryptosporidium spp., [17].

Chemical control of P. americana has been the most popular and effective method so far [18], but their control as insecticides is not a suitable because of several reasons; the most important of which is that they may develop resistance against certain frequently used insecticides [19].Non-conventional insecticides were used against P. americana exhibited a high efficiency in controlling the insect pest [20].

Natural products such as borax and boric acid are natural materials, and they are both contain the element boron. Usually, Borax is mined and refined from tourmaline, kernite and colemanite. In general, the two materials act the same and in theory, can control pests [21]. Boric acid has a long history as an insecticide in pest management, and it has been shown to be an effective alternative to conventional neurotoxic insecticides. Several borate-sugar combinations were evaluated in choice and no-choice assays in the laboratory. [22], showed that boric acid can be effective against cockroaches.

Much of the work regarding insecticidal efficacy has been done on German cockroaches, however, very little data is available about the effect of boric acid and borax against P.americana adults and nymphs in Jeddah governorate. Therefore, keeping in view the work carried out by various researchers, the present work was designed to investigate the insecticidal efficacy of boric acid and borax and the susceptibility of adults and nymphs to these insecticides through laboratory bioassay using feeding and contact toxicity methods.

MATERIALS AND METHOD

Experimental site

The laboratory bioassay were conducted at the Dengue Mosquito Experimental Station (DMES), belonging to the Department of Biological Sciences, Faculty of Sciences, King Abdul-Aziz University, Jeddah, Saudi Arabia.

Experimental insect

P. americana was collected from dark and damp places (sewers) from different areas in Jeddah province by using food jars surrounded by dark cloth as a trap [23]. The strains were stored in the lab and used in this study. Traps were placed into main sewers. Cockroaches were collected every two days and placed in glass containers (30 × 60 × 30 cm). Then, they were thus kept under the laboratory condition of 25 ± 3 °C and 75 ± 5 % RH.

Chemicals

Boric acid and borax insecticides were used during bioassay against P. americana adult and nymphs. The choice of these insecticides was based on the fact that those chemicals have not been tested against different stages of P. americana in Jeddah governorate so far and their low coast. All chemicals were obtained from AL- ShafeiMedica & Scientific Equipment. Jeddah, Saudi Arabia.

Feeding and contact toxicity bioassay of boric acid and borax were used in this study and different concentrations were used against adults and nymphs after 48h. of exposure periods.

Feeding bioassay

Feeding bioassay was done according to [24], with some modifications against adults and nymphs. For the present study, Bait was improvised in the laboratory. Feeding bioassays were conducted with lab strains using previous plastic boxes coated with petroleum jelly 2 cm from the inside top to prevent the cockroaches from escaping. 1gm of white floor, 1gm of powder milk, 1gm of sugar were prepared manually and treated with different concentrations of insecticides and appropriate amount of water to make semisolid bait. A single pellet was large enough to be entirely eaten by adults or nymphs starved for 24 h. Treated pellets were dried in a fume hood for 15-20 min. A single pellet was then provided to adults and nymphs held in approximately 3-4 gm. Control insects received treated pellets only with water. Each replicate consisted of 30 insects and three replicates for each concentration. Mortality was assessed after 48 h.

Contact toxicity bioassay

Contact toxicity bioassay was done according to [25], with some modifications against adults and nymphs. Contact toxicity mixture was improvised in the laboratory. Contact bioassays were conducted with previous method. Liquid mixture was then conducting by spraying different concentrations of the insecticide from inside plastic box and make sure that the insecticide covered all the sides. Three plastic boxes with 30 cockroaches (adults and nymphs) were used for each concentration.

Statistical analysis

This study was completely randomized design (CRD) in a factorial experiment. The data were statistically analyzed using analysis of variance (ANOVA), and means were compared by LSD at P ≤ 0.05 SAS software program. LC_{50} and LC_{90} were calculated according to Probit analysis program [26].

RESULTS

Mortality of adults and nymphs resulted after feeding bioassay with boric acid was summarized in Table (1) after 48 h. of exposure. Mortality percentage were highly increased by increasing concentrations at all exposure intervals for adults and nymphs. After 48 h.,boric acid gave level of mortality to adults and nymphs (10.00, 33.33%) at concentrations (0.1%), and after 42 h., for adults and nymphs. In the susceptibility level of nymphs and adults of P.americana after 48 h. of continuous exposure to residue of boric acid, figure (1) illustrated that the nymphs were more sensitive to boric acid by LC_{50} values (0.131 %) than adults (0.541%). Contact toxicity bioassay of boric acid was resulted also in table (1), and the results shows that low concentrations exhibited high mortality to adults and nymphs (73.33 %) after 48 h. between concentrations of (0.03-0.5 %). The susceptibility level of adults and nymphs of P.americana after 48 h. of continuous exposure to residue of boric acid are illustrated in figure (2). The nymphs were more sensitive to boric acid by LC_{50}'s values (0.103%) followed by adults (0.117 %) after 48 h. of exposure.

For feeding bioassay with borax, mortality percentage were highly increased by increasing concentrations at all exposure intervals for adults and nymphs as in table (2). After 48 h. borax gave level of mortality between 23.33 and 90.00 %between the concentrations 0.005 and 1 % for adults and mortality between 46.66 and 96.66 % between the concentrations of 0.001 and 0.1 for nymphs after 48 h. Figure (3) illustrated that the nymphs were more sensitive to borax by LC_{50} values (0.0.006 %) than adults (0.034 %). For contact toxicity of Borax, was recorded also in table (2) and figure (4). There was positive correlation between mortality of borax concentrations and exposure intervals.

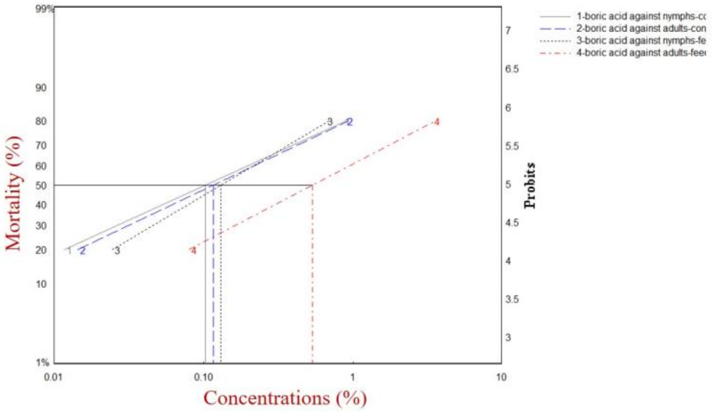

Fig 1: Comparison between the susceptibility of P.americana adults and nymphs against boric acid using feeding and contact toxicity method after 48h. using LDP line program

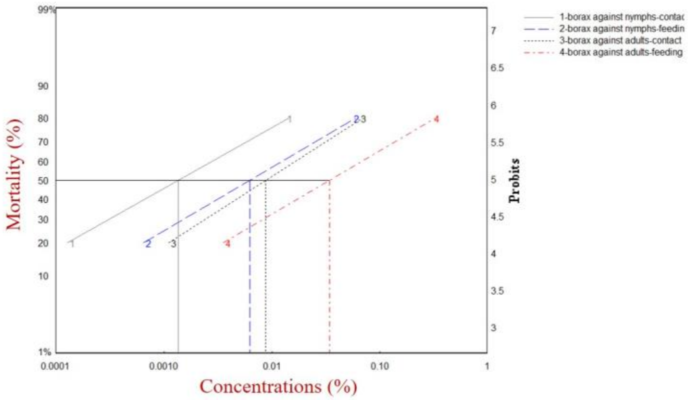

Fig 2: Comparison between the susceptibility of P.americana adults and nymphs against borax using feeding and contact toxicity method after 48h. using LDP line program

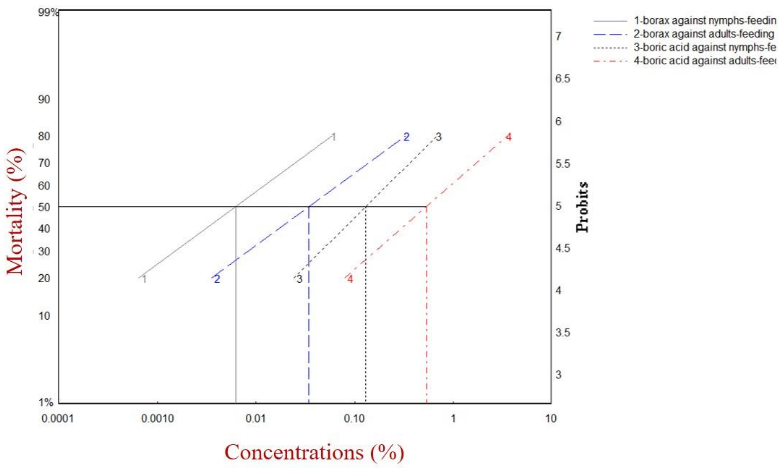

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Fig 3: Comparison between the susceptibility of P.americana adults and nymphs against boric acid and borax using feeding method after 48h. using LDP line program

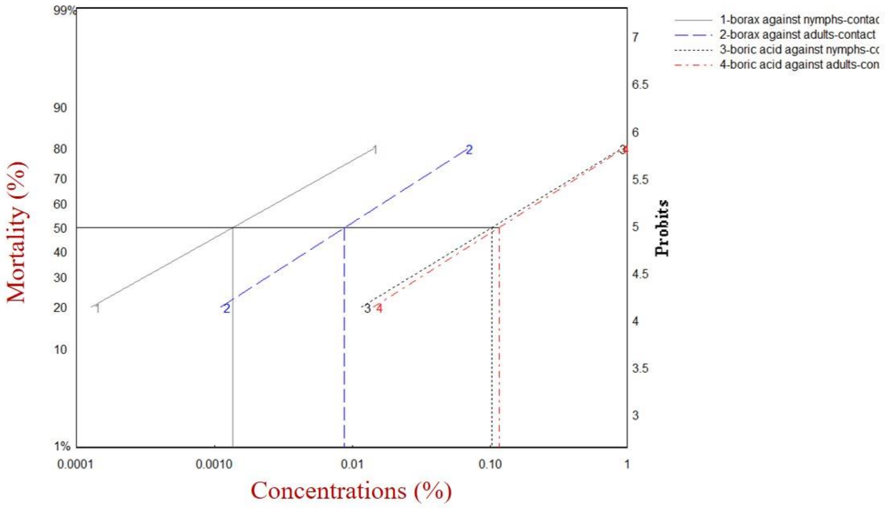

Fig 4: Comparison between the susceptibility of P.americana adults and nymphs against boric acid and borax using contact toxicty method after 48h. using LDP line program

Table 1: Susceptibility adults and nymphs of P.americana to boric acid using feeding and contact toxicity methods after 48h.

Treatment	Parameters					
	Con. (%)	**Mortality (%)**	**LC_{50} (L-U)**	**LC_{90} (L-U)**	**X^{2*}**	**Slope**
Adult / Feeding	0.1 – 20.0	23.33 - 96.66	0.541 (0.397-0.707)	9.848 (6.919-15.36)	5.243	1.017
Adult / Contact	0.03 – 0.5	26.66 – 73.33	0.117 (0.087-0.157)	2.844 (1.376-9.764)	2.75	0.925
Nymph / Feeding	0.05 – 3.0	30.00 – 96.66	0.131 (0.097-0.170)	1.683 (1.190-2.653)	5.461	1.158
Nymph / Contact	0.01 – 0.5	20.00 – 90.00	0.103 (0.070-0.161)	2.836 (1.185-12.937)	2.425	0.8921

LC_{50}=lethal concentration that kill 50% of the treated insects, LC_{90}= lethal concentration that kill 90% of the treated insects, U: upper limit, L: lower limit,

* X^2= Calculated Chi square, tabulated Chi^2= 7.8

When tabulated $(Chi)^2$ larger than calculated at 0.05 level of significance indicates the homogeneity of results.

Table 2: Susceptibility adults and nymphs of P.americana to borax using feeding and contact toxicity methods after 48h.

Treatment	Parameters					
	Con. (%)	Mortality (%)	LC_{50} (L-U)	LC_{90} (L-U)	X^{2*}	Slope
Adult / Feeding	0.005 – 1.00	23.33 – 90.00	0.034 (0.025-0.046)	1.087 (0.655-2.137)	0.380	0.855
Adult / Contact	0.001 – 0.5	20.00 – 96.66	0.0088 (0.0065-0.0117)	0.207 (0.1365-0.3516)	2.344	0.935
Nymph / Feeding	0.001 – 0.1	30.00 – 93.33	0.0063	0.1974	12.60	0.856
Nymph / Contact	0.001 – 0.1	46.66 – 96.66	0.0014 (0.0007-0.0022)	0.050 (0.0313-0.0971)	2.397	0.820

LC_{50}=lethal concentration that kill 50% of the treated insects, LC_{90}= lethal concentration that kill 90% of the treated insects, U: upper limit, L: lower limit,
* X^2= Calculated Chi square, tabulated Chi^2= 7.8
When tabulated $(Chi)^2$ larger than calculated at 0.05 level of significance indicates the homogeneity of results.

DISCUSSION

In search of the best low cost, efficient and non-toxic insecticide for controlling P.americana, a number of experiments were carried out here. In this study P.americana was treated with boric acid and borax. This study reveals interesting comparisons between boric acid and borax for controlling adults and nymphs of P.americana. Natural products such as borax and boric acid are origin insecticides with limited or no adverse effects on the environment or beneficial organisms or low risk insecticides Mohamedet al., 2014. In general, the two materials act the same and in theory, can control pests [21].In our study, different concentrations of boric acid and borax were used against adults and nymphs of P.americana after 48 h., of exposure by feeding and contact toxicity methods. Data from this study explain that the toxicity of borax showed high mortality than boric acid again adults and nymphs of P.americana by contact method than feeding one. It is difficult to explain this results, but it might be because of the humidity of the environment which effect on the mode of action of borax when use it by contact toxicity method. However, much of the work has been done on boric acid, and very little data is available about the effect of borax on cockroaches. In both treatments, mortality increased by increasing the concentrations. Similar results were obtained by[28] who have reported that increasing concentrations of boric acid were toxic to P. americana and mortality percentage increased in a positive correlation with concentration. Agree with our results, [28], found that sprays and liquid baits insecticides are effective in controlling cockroaches, and they work efficiently and even a very small amount. This is in agreement with [27], who used boric acid in liquid bait which effectively killed cockroaches. Studied conducted by[23] who have reported that boric acid can be used for the control of cockroaches. [29], reported that boric acid acts as a stomach poison affecting the insects' metabolism and the dry powder affects the exoskeleton cuticle and when ingested boric acid it causes structural alterations in the mid-gut of cockroach. In another study, [30]showed that there was a synergistic interaction between boric acid and Metarhiziumanisopliae, and they killed cockroaches significantly faster than without boric acid.

CONCLUSIONS

In the light of above mentioned finding, it can be suggested that boric acid can be used against different stages of P. americana at all localities of populations in Jeddah governorate, because it is an effective and low coast inorganic insecticide, with safety use to the human and the environment.

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