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Effect of boric acid on mortality rate of German cockroach (*Blattella germanica*)

Myrul Islam**Abstract**

The effect of boric acid on German cockroach is studied in 2016 at Dehradun. It was studied that how boric acid affects German cockroach over time. Boric acid can be used as an antiseptic for minor burns or cuts and is sometimes used in dressings or salves. Boric acid is applied in a very dilute solution as an eye wash. Dilute boric acid can be used as a vaginal douche to treat bacterial vaginosis due to excessive alkalinity, as well as candidiasis due to *Candida albicans*. The German cockroach occurs widely in human buildings, but these are mostly associated with hotels, kitchen, restaurants, and nursing homes (Hospital) and in cold climates, they occur only near human dwellings, because they cannot survive severe cold. However, though they would soon die in the outdoors on their own, German cockroaches have been found as inquilines of human buildings as far north as Alert, Nunavut. German cockroaches produce odorous secretions that can affect the flavor of various foods. When the cockroach's populations are high, these secretions may result in a characteristic odor in the general region of the infestation [2-4]. Disease-producing organisms such as bacteria, protozoan, and viruses have been found on cockroach bodies. German cockroach, which is easily available in every household of Dehradun was taken for experimentation. For this purpose, 84 cockroaches were collected and divided into 3 groups. Each group contains 7 cockroaches. These cockroaches were exposed to three forms of boric acid- solid+ flour, water, at different concentration - 25%, 50% and 75%. It was observed that at 25% concentration in all 3 forms, the cockroach mortality rate is quite low; but with increase in concentration of boric acid the mortality increase. Highest mortality was reported at 75% concentration of boric acid. So, in this way boric acid is quite effective in control of these dreadful species of Phylum Arthropod [7].

Keywords: Effect, boric acid, mortality rate, German cockroach

Introduction

Cockroaches are insects of the order Blattodea, which also includes termites. About 30 cockroach species out of 4,600 are associated with human habitats. About four species are well known as pests. The cockroaches are an ancient group, dating back at least as far as the Carboniferous period, and some fossil evidence indicates that cockroaches have been on earth for over 300 million years. Those early ancestors however lacked the internal ovipositors of modern roaches. Cockroaches are somewhat generalized insects without special adaptations like the sucking mouthparts of aphids and other true bugs; they have chewing mouthparts and are likely among the most primitive of living neopteran insects [9, 10]. They are common and hardy insects, and can tolerate a wide range of environments from Arctic cold to tropical heat. Tropical cockroaches are often much bigger than temperate species, and, contrary to popular belief, extinct cockroach relatives and 'roachoids' such as the Carboniferous *Archimylacris* and the Permian *Apthoroblattina* were not as large as the biggest modern species. Some species, such as the gregarious German cockroach, have an elaborate social structure involving common shelter, social dependence, information transfer and kin recognition. Cockroaches have appeared in human culture since classical antiquity. They are popularly depicted as dirty pests, though the great majority of species are inoffensive and live in a wide range of habitats around the world. Cockroaches are among the most common of insects [15, 16]. They're considered one of the most successful groups of animals. Because Cockroach are so adaptable, they have successfully adjusted to living with humans. The German cockroach is a widely distributed urban pest. It is also the most common cockroach species in house, apartments, restaurants, kitchen, storehouse, hotels, and other institutions. This is true not only in Pennsylvania but also throughout the United States and in most parts of the civilized world [20]. Adult German cockroaches are 1/2 to 5/8 inch long and tan to light brown. Although they have fully developed wings, they do not fly. Nymphs are similar in

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appearance to do adults except that they are smaller and lack wings. The German cockroaches is best identified by its small size and by two dark parallel lines running from the head to the wings. It is usually found in kitchens and in bathrooms of homes [25].

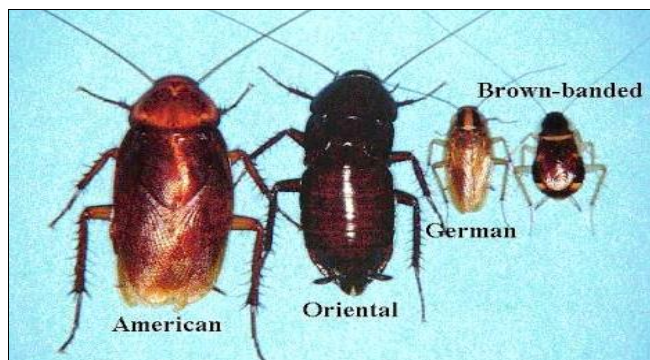


Fig 1: Species of Cockroach

German cockroaches usually prefer a moist environment with a relatively high degree of warmth. The insects are mostly scavengers and will feed on wide variety of foods. They are especially fond starches, sweets, grease, meat products. As with other species, German cockroaches are mostly active at night for feeding. In one year over 10,000 descendants can be produced, assuming two generations per year [23]. German cockroaches produce odorous secretions that can affect the flavor of various foods. When the cockroach's populations are high, these secretions may result in a characteristic odor in the general region of the infestation. Disease producing organisms such as bacteria, protozoan, and viruses have been found on cockroach bodies. Different forms of gastroenteritis like- food poisoning, dysentery, diarrhea, and other illnesses appear to be the principal diseases transmitted by German cockroaches. Instances of cockroaches penetrating ears, mouth, and nasal passages of humans inflicting extreme pain and causing inflammation are not uncommon [24] (Encyclopedia of Entomology, Volume 2 edit by John L. Capinera, p.951). Cockroaches are abundant throughout the world and live in a wide range of environments, especially in the tropics and subtropics. Cockroaches can withstand extremely cold temperatures, allowing them to live in the Arctic. Some species are capable of surviving temperatures of -188°F (-122°C) by manufacturing an antifreeze made out of glycerol. In North America, 50 species separated into five families are found throughout the continent. 450 species are found in Australia. Only about four widespread species are commonly regarded as pests.

Cockroaches occupy a wide range of habitats. Many live in leaf litter, among the stems of matted vegetation, in rotting wood, in holes in stumps, in cavities under bark, under log piles and among debris. Some live in arid regions and have developed mechanisms to survive without access to water sources [26]. Others are aquatic, living near the surface of water bodies, including bromeliad phytotelmata, and diving to forage for food. Most of these respire by piercing the water surface with the tip of the abdomen which acts as a snorkel, but some carry a bubble of air under their thoracic shield when they submerge. Others live in the forest canopy where they may be one of the main types of invertebrate present. Here they may hide during the day in crevices, among dead leaves, in bird and insect nests or among epiphytes, emerging at night to feed [27].

Materials and Methods

Experimental Insects: *Blatella germanica* (German cockroach) were used in the laboratory experiments. Cockroaches were reared in plastic trash cans with cardboard harborage at $25-28^{\circ}\text{C}$ 80% relative humidity under at 12:12 dark -light photoperiod. The cockroaches were provided *ad libitum* with water and dry dog food as previously described (Habes *et al*, 2006) [5].

Classification

Phylum	:	Arthropoda
Subphylum	:	Mandibulata
Class	:	Insecta
Subclass	:	Pterygota
Order	:	Orthoptera
Genus	:	<i>Blatella</i>
Species	:	<i>germanica</i>



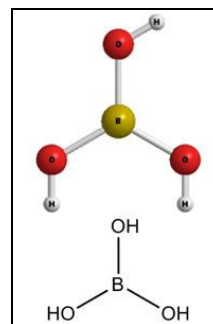
Fig 2: German cockroach (*Blatella germanica*)

We collected 105 cockroaches for experimental purposes which are divided into five groups, each containing three subgroups. Each subgroup contains seven cockroaches [17].

Experimental chemical: Boric acid

Properties of boric acid:

IUPAC Name:	Boric acid, Trihydroxidoboron
Common Name:	Orthoboric acid, Optibore, Sassolite Borofax
Chemical formula:	HB_3O_3
Molar mass:	61.83 gm./mole
Appearance:	White crystalline solid
Density:	$1.435/\text{cm}^3$
Melting point:	170.9°C (339.6°F , 444k)
Boiling point:	300°C (572°F , 573k) [7]



Structure of Boric acid

Preparation of boric acid

- 1) Concentration solid: 25% = 25gm boric acid was mixed with 75gm wheat flour.

- 2) Concentration solid: 50%= 50gm boric acid was mixed with 50gm wheat of flour.
- 3) Concentration solid: 75%= 75gm boric acid was mixed with the 25gm wheat flour.
- 4) Concentration solution: 25%= 25ml boric acid dissolved in 75ml of water.
- 5) Concentration solution: 50%= 50ml boric acid dissolved in 50 ml of water.
- 6) Concentration solution: 75% = 75ml boric acid dissolved in 25ml of water.

Table 1: showing the different concentrations of boric acid:

Dose of boric acid	Solution	Solid
25%	25ml of boric acid + 75m of water.	25gm of boric acid + 75gm wheat flour.
50%	50ml of boric acid + 50ml of water.	50gm of boric acid +50gm wheat flour.
75%	75ml of boric acid + 25ml of water.	75gm of boric acid+ 25gm wheat flour.

4. Determination of LT50

LT90 is the lethal time at which 50% mortality occurs. To determine the LT90 we divided the 105 cockroaches into two groups (boric acid+ water solution and boric acid with wheat flour.), each containing 7 cockroaches. Then we measured the time until the 90% mortality occurs. This time will be LT90.

5. Statistical calculations

In the present investigation, the following formulae were used for different statistical calculations after Fisher and Yates [16] (1963)

Mean

$$\bar{X} = \frac{\sum X}{N}$$

Where,

$\sum X$ = Sum of observations.

N= Total number of observations.

Standard Deviations (SD)

$$SD = \sqrt{\frac{\sum(X-\bar{X})^2}{N-1}}$$

Where,

$(X - \bar{X})^2$ = Sum of the square of the derivation from the mean.

N = Total number of observations.

Standard Error of Mean (S. Em)

$$S.Em = \frac{S.D}{\sqrt{N}}$$

Where,

S.D. = Standard Deviation

N= Number of Observations.

Students 't' test

The value of 't' was calculated by the followings formula-

$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{(S.Em_1)^2 + (S.Em_2)^2}}$$

Where,

$\bar{X}_1 - \bar{X}_2$ = Difference between means of control and experimental sets.

S. Em₁ = Standard error of the control set.

S. Em₂ = Standard error of the experimental set.

Degree of freedom

$$Df = n_1 + n_2 - 2$$

Where,

n₁ and n₂ number of items in the two samples.

Test of significance's'

The 't' values were signified by the Fischer's formula for significance test. The probability 'p' obtaining's' values for a given degree of freedom 'Df' was determined by comparing 't' values for a given degree of freedom 'Df'. The 'p' values were signified according to the following conventions:

Result and Discussion

LT50 for Different dose of Boric acid

LT50 for 25% boric acid:

The observe value of LT50 of 25% solid and solution of boric acid was 120 ± 21.2 minutes, LT50 of wheat Flour was 2076 ± 86.3 minutes.

We observed a significant decrease in LT50 for solid of boric acid in comparison to both boric acid flour of wheat.

LT50 for 50% boric acid

The observe value of LT50 of 50% solid and solution of boric acid was 63.± 6.90 minutes, LT50 of wheat Flour was 1452± 90.04 minutes.

We observed a significant decrease in LT50 for solid of boric acid in comparison to both boric acid flour of wheat.

LT50 for 75% boric acid

The observe value of LT50 of 75% solid and solution of boric acid was 39.2 ± 1.98 minutes, LT50 of wheat Flour was 432 ± 61.35 minutes.

We observed a significant decrease in LT50 for solid of boric acid in comparison to both boric acid flour of wheat.

Mortality rate observation in German cockroaches

Table 2: Concentration (Solid) = 25gm of boric acid+ wheat flour. Total number of cockroaches in each reading = 7

Time	Observation time	Mortality rate					Mean.
12 noon-2 pm	2 hours	1	1	0	1	1	0.8
2pm-4pm	2 hours	0	1	1	1	0	0.6
4pm-6pm	2 hours	1	0	1	0	0	0.4
6pm-8pm	2 hours	0	1	0	0	1	0.4
8pm-10pm	2 hours	0	1	0	1	0	0.4

Table 3: Concentration (solid) = 50gm of boric acid+ Wheat flour. Total number of cockroaches in each reading = 7

Time	Observation time	Mortality rate					Mean.
11am -12 pm	1 hours	1	2	0	1	1	1
1pm-2pm	1 hours	0	1	1	0	2	0.8
2pm-3pm	1 hours	1	1	1	0	2	1
3pm-4pm	1 hours	0	1	1	2	2	1.2
4pm-5pm	1 hours	2	0	2	1	1	1.2

Table 4: Concentration (solid) = 75gm of boric acid + Wheat flour. Total number of cockroaches each reading= 7

Time	Observation time	Mortality rate					Mean.
12pm -1 pm	1 hours	0	1	2	1	2	1.2
1pm-2pm	1 hours	1	2	1	2	0	1.2
2pm-3pm	1 hours	2	1	2	1	1	1.4
3pm-4pm	1 hours	1	2	1	2	1	1.4
4pm-5pm	1 hours	2	1	1	1	2	1.4

Table 5: Concentration (solution) = 25ml of boric acid + 75ml of water. Total number of cockroach in each reading = 7

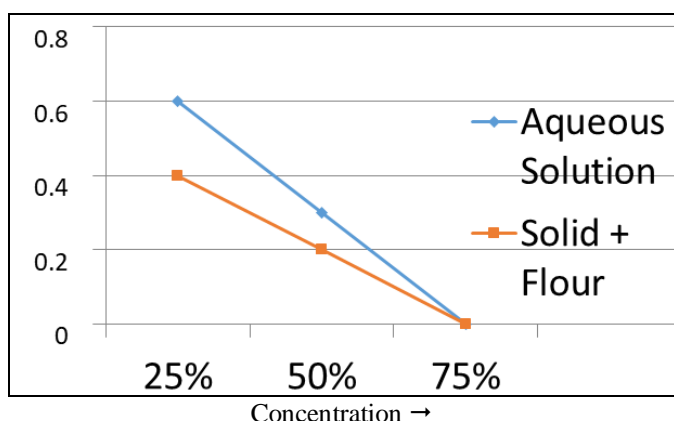
Time	Observation time	Mortality rate					Mean.
11am -12 pm	1 hours	1	0	0	1	0	0.4
1pm-2pm	1 hours	1	0	1	0	1	0.6
2pm-3pm	1 hours	0	1	0	1	1	0.6
3pm-4pm	1 hours	1	1	1	0	1	0.8
4pm-5pm	1 hours	1	1	0	0	1	0.4

Table 6: Concentration (solution) = 50ml of boric acid + 50ml of water. Total number of Cockroach in each reading = 7

Time	Observation time	Mortality rate					Mean.
10am -11 am	1 hours	1	1	1	0	1	0.8
11am-12pm	1 hours	1	2	0	2	1	1.2
12pm-1pm	1 hours	1	2	2	1	0	1.2
1pm-2pm	1 hours	1	0	1	1	2	1
2pm-3pm	1 hours	0	1	1	2	2	1.2

Table 7: Concentration (solution) = 75ml of boric acid + 25ml of water. Total number of Cockroach in each reading = 7

Time	Observation time	Mortality rate					Mean.
10am -11 am	1 hours	2	1	1	2	1	1.4
11am-12pm	1 hours	1	0	1	1	1	0.8
12pm-1pm	1 hours	1	2	1	0	1	1
1pm-2pm	1 hours	1	2	1	2	2	1.4
2pm-3pm	1 hours	2	1	1	1	2	1.4



Graph showing the LT50 for different doses of boric acid

Cockroaches are move freely from building to building or from drains, garden, sewers and latrines to human habitations. Because they feed on human faces as well as human food they can spread germs that cause disease. Cockroaches are not usually the most important cause of a disease, but like houseflies.

Cockroaches can spread disease by contaminating human food with germs they pick up in latrines, garbage dumps, etc. they may play a supplementary role in the spread of some diseases. They are proven or suspected carriers of the organisms causing:

- diarrhea
- dysentery
- cholera
- leprosy
- plague
- typhoid fever
- viral diseases such as poliomyelitis.

In addition they carry the eggs of parasitic worms and may cause allergic reactions including dermatitis, itching, swelling of the eyelids and serious respiratory conditions (Stankus *et al*, 1990).

Stankus RP, Horner E, Lehrer SB. Identification and characterization of important Cockroaches allergens. *Journal of allergy and clinical immunology*, 1990, 86: 781-787.

Boric acid is a wonderful tool for controlling cockroaches in homes, restaurants and other buildings. It is effective in extremely small amounts and retains its potency almost indefinitely provided the deposit remains dry. Unlike many insecticides, boric acid has no repellency to insects and, consequently, roaches return to treated areas repeatedly until they die. Boric acid is deadly to cockroaches, but is low in toxicity to people, pets and other non-target animals. It is also odorless and contains no volatile solvents. Cockroaches succumb to boric acid when they crawl over treated areas. The tiny particles of powder adhere to the cockroach body and material is ingested as the roach preens the powder from its legs and antennae. Some boric acid is also absorbed through the greasy outer covering of the insect's body. All species of cockroaches are susceptible to boric acid provided the powder is applied into areas where the cockroaches are living the key success with boric acid is proper application. For best results the powder should be applied in very thin layer barely visible to the naked eye. Kitchen and bathrooms are the most common areas to find cockroaches, although any area of a home may become infested if the infestation is severe, or if species other than the German cockroaches are involved [29]. Key areas for treatment include under/behind the refrigerator, stove and dishwasher, into the opening where plumbing pipes enter walls and into cracks along edges and corners inside cabinets and bathroom cabinets which becomes a hiding place for cockroaches. This area can be accessed and treated by injecting powder through any existing gap at the top of the kick plate, or if none is present, by drilling a few small holes. Never apply boric acid onto countertops or other exposed surfaces, especially those used to prepare food. Any visible residues should be wiped off with a damp cloth. Boric acid can be used alone or in combination with other cockroach control products.

Registered in 1983 for control of cockroaches, ants, grain weevils and several beetles. It has been shown to attack their nervous system as well as being a drying agent to their bodies. Boric acid is a wonderful tool for controlling cockroaches in homes, restaurants and other buildings. It is effective in extremely small amounts and retains its potency almost indefinitely provided the deposit remains dry. Unlike many insecticides, boric acid has no repellency to insects and, consequently, roaches return to treated areas repeatedly until they die. Boric acid (100%) powder is odorless and non-staining. Boric acid deadly to cockroaches to cockroaches, but is low in toxicity to people, pets and other non-target animals. It is also odorless and contains no volatile solvents [30].

People have been fighting cockroaches with boric acid for nearly a century cockroaches succumb to boric acid when

they crawl over treated areas. The tiny particles of powder adhere to the cockroach's body and the material is ingested as the roach preens the powder from its legs and antennae. All species of cockroaches are susceptible to boric acid provided the powder is applied into areas where the roaches are living [31]. Boric acid has its effect on non-target organisms, but limited studies have suggested that boron exposure may play a role rates. Ingestion of small amounts of boric acid or borate salts by animals has resulted in clinical signs that include excessive salivation, thirst, vomiting and fever, retching, depression, loss of appetite, diarrhea, and abdominal pain. The vomit or stools of exposed animals may contain blood or have a blue- green color.

Conclusion

Cockroach belongs to Phylum Arthropod. They are the most grief organisms which is harmful to man. They prefer to live in cracks; crevices etc. and are active at night. They take fluid materials and spoil the food and cause dysentery, diarrhea, cholera etc. They can be controlled by mechanical or chemical means. Among chemical means, boric acid is one of the means. It causes an effect on cockroach only and quite harmless on humans [18]. As this dissertation is based on the effect of boric acid on cockroach, German cockroach, which is easily available in every household of Dehradun was taken for experimentation. For this purpose, 84 cockroaches were collected and divided into 3 groups. Each group contains 7 cockroaches. These cockroaches were exposed to three forms of boric acid- solid+ flour, water, at different concentration - 25%, 50% and 75%. It was observed that at 25% concentration in all 5 forms, the cockroach mortality rate is quite low; but with increase in concentration of boric acid the mortality increase. Highest mortality was reported at 75% concentration of boric acid. So, in this way boric acid is quite effective in control of these dreadful species of Phylum Arthropod [32, 33].

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