Response of Periplaneta americana (L.) to novel boric acid bait

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A novel boric acid-based toxic bait was formulated, screened and evaluated for its efficacy against *P. americana*. The bait was prepared using boric acid, flour, and honey mixed in 3 : 5 : 2 proportion by weight in boiling water to give a paste-type formulation. Response of American cockroaches to boric acid bait was evaluated in no choice tests. Percentage boric acid bait consumption was used to estimate relative attractancy/repellency of the bait. Reduced bait-repellency, allowed initial consumption of bait by *P. americana*. Delayed toxicity of initially ingested boric acid forced progressive starvation which resulted in decrease in bait consumption, body protein concentration and survival of *P. americana* as the period of exposure to the bait increased. The results suggest that relation between amount of bait eaten and body protein concentration might be a better indicator of longevity of *P. americana*, when compared over period of exposure. Our findings are important because these may re-establish boric acid as a prominent roach-control chemical in 'cockroach management programmes'.

COCKROACHES can be controlled by various methods that include crack and crevice treatments, baseboard sprays, aerosols, foggers, and baits. Baits are presumably attractive formulations of insecticides in water or food that are toxic when ingested[1]. Control of cockroaches by the use of toxic baiting has a long and varied history. Baits have become increasingly useful in cockroach management programmes in recent years[2]. Use of baits results in less environmental contamination and greater ease of application than other insecticidal products. However, effective bait formulation must be palatable and thus nonrepellent, readily available, toxic to the pest in amounts consumed, and have good stomach poison action[3].

Boric acid has been used as an insecticide for many years, especially against cockroaches. It is well known that toxic baits containing boric acid, phosphorus and other compounds are effective against *Periplaneta* spp. and other large peridomestic cockroach species[4,5]. However, varying levels of control in the use of boric acid and other baits in the control of cockroaches have been reported[6,7]. Recently, use of boric acid has been limited because it is a slow acting poison requiring several days to produce a significant population reduction compared to most of the nerve poisons in current use, which cause high mortality within 24–48 h. A major resistance problem against many of the latter insecticides has developed which has greatly diminished their usefulness, and as a result interest has again centered on lesser-used compounds, including boric acid[8]. Reported here are the results of efficacy of one such novel boric acid bait formulated against *P. americana*. Such studies are useful in developing application strategies for boric acid-based bait and for its use in cockroach control protocols to assist IPM programmes.

For the test insects, field collected *P. americana* adults were maintained in the laboratory for at least 6 to 8 weeks at 25 ± 2°C, 60–70% RH and 12 : 12 L : D photoperiod. During this period they were fed on diet having same composition of that of 'control bait'.

Wooden test chambers 4′ × 4′ × 4′, were fabricated; each having stainless steel mesh on two opposite sides and small circular opening of 0.5′r with lid at the top.

For experimentation, the chemical and other materials used were: boric acid (H_3BO_3, MW-61.83, LOBA Chemie), honey (Grade 'A', Charak Healthcare Pvt Ltd). The baits were prepared using boric acid mixed with wheat flour and honey in 3 : 5 : 2 proportion by weight in boiling water to give paste-type formulation. Control bait was prepared similarly but without boric acid. To stabilize paste-type formulation of the bait, that deteriorates too rapidly, it was prepared in boiling water since solubility of boric acid is highest at 100°C. Dehydration of the bait was controlled, which otherwise becomes dry as well as brittle, using thin film of paraffin sprayed on the bait surface, which allowed consumption of bait but reduced its contamination.

For carrying out no choice test, in two test chambers – labelled as control and treated – hundred adults of *P. americana*, derived from laboratory stock, were kept and offered control and treated baits respectively. The two test chambers had five glass petri dishes (9 cm diameter): four, each with 10 g of bait – either control or treated – were placed at the four corners; and one, with moist cotton swab, towards the center of test chamber. Two black construction papers, 3′ × 10 cm, rolled and perforated, were placed in each of the test chambers where adults were settled in harborages and from which they had to forage for food as well as water. Amount of bait consumed, body protein concentration and survival rate of *P. americana* were recorded. For each test, five replicates were taken and all the tests were repeated thrice.

For bait consumption, baits from control and boric acid treated were weighted daily, and bait consumption was computed as:

$$\text{Daily bait (control/boric) consumption (mg/insect)} = \frac{(\text{wt of bait at day 0}) - (\text{wt of bait at day 1})}{\text{Total no. of insects}}$$

For bait palatability, percentage boric acid bait consumption

Table 1. Effect of boric acid on bait consumption, total body protein concentration and survival rate of adult *P. americana* during ten days exposure

Exposure period (days)	Bait consumption (mg/insect)		Boric bait consumption	Survival (%)		Body protein concentration (mg/g body wt)	
	Control	Boric	(%)	Control	Boric	Control	Boric
0	0	0	0	100	100	28.19(± 1.7)	28.19(± 1.7)
1	24.03	17.20	71.57	100	99.6	–	–
2	32.10	23.57	73.42	100	96.2	28.02(± 1.3)	27.78(± 0.8)
3	27.07	9.19	33.94	98.1	94.1	–	–
4	21.30	2.05	9.62	98.7	91.4	27.89(± 1.7)	27.11(± 0.9)
5	18.21	0.23	1.26	95.3	88.6	–	–
6	23.37	0	0	94.6	83.5	27.66(± 0.5)	24.69(± 1.4)
7	26.76	0	0	93.0	72.2	–	–
8	24.98	0	0	90.6	61.0	27.42(± 1.1)	20.04(± 1.4)
9	23.33	0	0	87.5	47.3	–	–
10	19.79	0	0	83.9	23.4	27.17(± 1.8)	15.28(± 1.3)

was used to estimate relative attractancy/repellency of bait as:

$$\text{\% Boric acid bait consumption} = \frac{\text{Boric acid bait consumption at day 0}}{\text{Control bait consumption at day 0}} \times 100.$$

Comparisons of attractancy were based on the extent to which bait consumption exceeded 50%; estimates of relative repellency, on the degree to which bait consumption was lower than 50% (ref. 2).

For body protein estimation, five live *P. americana* were removed from each replicate of control as well as boric test chambers and utilized separately for whole body protein estimation, at two days interval. They were weighed, and after removal of wings and legs, homogenized with 1 M phosphate buffer (pH = 6.5; vol = 5 ml/insect). The homogenate was centrifuged at 2500 rpm, at 4°C for 10 min. Supernatant was used for protein estimation. Protein content in whole body extract of *P. americana* was determined quantitatively by Lowry's method[9] and OD was measured at 560 nm.

Longevity of *P. americana* was measured in terms of percentage survival. The number of live and dead insects per replicate was recorded to assess survival.

Thus, it is apparent from Table 1 that amount of bait consumed, body protein concentration and survival rate of *P. americana* decreases as a function of time in boric acid treatment. Boric acid bait consumption exceeds 50% initially up to two days, indicating reduced repellency of the bait but effective enough to exert toxicity in the amounts consumed. It has been well documented that bait density has no relation with degree of control[10], however, bait palatability significantly influences amount of bait eaten and ultimately its efficiency[3]. It was observed that reduced bait repellency allowed initial bait consumption, which fell by day 2, and subsequently average bait consumption became less than 1 mg/insect by day 5 which might be as a result of forced starvation owing to delayed toxicity of initially ingested boric acid. The delayed toxicity of ingested boric acid destroys the cellular lining of foregut of cockroach and was sufficient to bring about the death of the insect, ultimately by starvation[8]. Body protein level was considerably decreased in *P. americana* fed on boric acid, especially by day 8, however, as pointed out earlier, percentage of fat might be a better indicator of the amount of bait eaten compared with period of starvation[11,12]. Longevity of *P. americana* was significantly reduced in case of boric acid bait which was 23.4% over a period of ten days. This is similar to the results reported earlier for *B. germanica*[13]. Thus, longevity of *P. americana* was significantly reduced by novel boric acid bait. Increased efficacy of the bait might be because of the use of finely powdered boric acid in paste-type formulation, as has been shown earlier that particle size of boric acid is important for its lethal but delayed toxicity[14]. However, the paste-type formulation showed higher insecticidal activity than tablet formulation. This could be because the former allows lower concentration of active ingredient being used[15,16]. Reduced bait-repellency is perhaps owing to low concentration of boric acid in bait. It has been found that amount of bait consumed is inversely related to the concentration of active ingredient[17]. Such cockroach killing agents are not only found effective in controlling cockroaches, but are also cost effective, as these use minimum and readily available cheap components. Moreover, a paste-type bait formulation is particularly well suited for application to cracks, crevices and other pest pathways. However, development of resistance to such bait has not yet been reported, as has been shown in case of *B. germanica* to commercial bait[18,19]. As an effective IPM tool, combination of bait constituents with fecal extracts to enhance performance in presence of alternative food source and application of such baits with residual

toxicants in bait trays might be helpful to achieve increased efficacy[20,21].

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ACKNOWLEDGEMENTS. We thank Dr S. N. Mukherje Pune, for critical review of the manuscript.

Received 21 April 1998; revised accepted 29 December 1998

MEETINGS/SYMPOSIA/SEMINARS

Radar Symposium India-99

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