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ABSTRACT: House rats (Rattus rattus) which do not consume a lethal dose of zinc phosphide develop poison-shyness after a single exposure. The surviving poison-shy rats cannot be baited again with zinc phosphide for about three months. Poison-shy rats were separately given anticoagulant baits (brodifacoum 0.005%, coumatetralyl and warfarin 0.025%) in no-choice tests. The first two anticoagulants were found to be the most efficient ones. It was observed that those R. rattus which had consumed 56.7 mg/kg or more zinc phosphide died sooner ($P < 0.05$ to 0.1) after anticoagulant poisoning when compared with normal rats. It is conjectured that prothrombin inhibition is accelerated in the liver of poison-shy R. rattus due to the action of phosphine present in the earlier ingested sublethal dose of zinc phosphide.

INTRODUCTION

It has been established that field as well as commensal rodents develop poison aversion and bait-shyness after a single exposure to the widely used rodenticide, zinc phosphide (Bhardwaj and Khan 1979, Prakash and Jain 1971, Prakash et al. 1975). The persistence of shyness in rodents which are not prebaited prior to poison baiting is of a higher magnitude than in those which are exposed to the toxicant after prebaiting (Bhardwaj and Prakash 1982). The development of poison aversion and bait-shyness among rodents of economic Importance makes the control of any residual population surviving a zinc phosphide baiting operation (the poison-shy rodents) a difficult task, since bait carrying the same poison on the second day is not accepted by them (Bhardwaj and Prakash 1979). We present the results of our attempts to evaluate the efficacy of three anticoagulants for controlling poison-shy residual populations of R. rattus.

METHODS

Rattus rattus rufescens (N = 205, average body weight 114.6g ± 12.5) captured from food grain godowns and residential premises around Jodhpur were acclimatized to laboratory conditions by maintaining them for 10 days on Jowar (Sorghum vulgare) in individual cages. Thereafter, groups of rodents were exposed to zinc phosphide for 24 hours by mixing it in millet (Pennisetum typhoides) flour at various dosages (20 to 60 mg/kg). The surviving (poison-shy) rats were observed for three days and were separated into three groups which were separately given anticoagulants, viz., brodifacoum 0.005%, coumatetralyl 0.025%, and warfarin 0.025%. The anticoagulants were mixed with millet grains + 5% arachis oil and provided to rats in no-choice tests. Mortality of rats and time to death were observed. The control experiments on rats feeding on zinc phosphide (Table 1) for one day and anticoagulants for five to 14 days (Table 2) were run simultaneously.

Table 1. Intake of zinc phosphide (mg/kg) and mortality of Rattus rattus after one day of exposure.

Poison intake (mg/kg)	Mortality up to 15 days
20	0.6
27	0/6
31	0.5
37	0/6
42	0/6
49	0/5
57	0/5
58	0/6
59	0/6
81	5/5
89	5/5
94	5/5

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Table 2. Time to death after feeding on anticoagulants of Rattus rattus that had not been exposed to zinc phosphide.

Poison	% Active ingredient in bait	Poison bait intake (g/100 g body weight)	Mortality	Days to death
Brodifacoum	0.005%	8.21 ± 2.06	6/6	4.5
Racumin	0.025%	8.09 ± 1.48	5/5	6.5
Warfarin	0.025%	8.39 ± 1.87	5/5	12.5

RESULTS AND DISCUSSION

It is evident that consumption of zinc phosphide up to 59 mg/kg did not kill R. rattus (Table 1). In the other control group of rats which had had no experience of feeding on zinc phosphide bait, all individuals died after feeding on brodifacoum, coumatetralyl and warfarin within 5-6, 6-8 and 13-14 days respectively (Table 2).

The group of poison-shy rats, which were earlier exposed to different dosages of zinc phosphide, died within 2-6 days after feeding on baits with brodifacoum, 3-8 days with coumatetralyl and 9-13 days with warfarin (Table 3). Apparently the time to death from anticoagulant poisoning of the rodents which had consumed sublethal dosages of zinc phosphide earlier was considerably reduced as compared to rats which fed on anticoagulant poisons without first being exposed to zinc phosphide. It is quite possible that the presence of phosphine at a sublethal level in their blood and liver makes them sick and prothrombin inhibition is accelerated after ingestion of the anticoagulants. As a consequence the time to their death is reduced. The presence of phosphine in the liver of dead rats was detected (Curry et al. 1959) when rats were fed a dose of zinc phosphide in excess of LD_{50}. Our conjecture that presence of phosphine in the body of R. rattus prior to consumption of anticoagulants increases the efficiency of the latter finds support from the observation that with an increasing quantity of ingested zinc phosphide, the time to death due to any of the three anticoagulants decreased (Table 3).

In spite of the fact that to minimize hazards acute rodenticides like zinc phosphide should not be used for the control of commensal rodents in residential premises and food grain godowns, this acute toxicant is being used and recommended by certain agencies in India. In the rural environment, when control operations are undertaken by farmers, success does not usually exceed 70-80 percent. It is this residual population of R. rattus which exhibits poison aversion and bait-shyness, making control difficult unless the poison and the bait are changed (Prakash and Jain 1971).

The present study clearly indicates that R. rattus, which have survived a zinc phosphide poisoning, can be effectively controlled by treating them with 0.005% brodifacoum or 0.025% coumatetralyl. Warfarin takes longer time but has the advantage that it is indigenously manufactured. Of the three anticoagulant rodenticides, brodifacoum was found to be most effective. These results agree with those of our earlier studies (Mathur and Prakash 1981, 1981a).

Another noteworthy finding is that after one day's exposure to zinc phosphide the speed of death due to anticoagulant poisoning was increased, particularly if the initial application of zinc phosphide was prebaited (Table 3). Whether or not this increased speed of death is of economic importance by saving food grains, poison and labour should be the criterion for recommending that both poisons--zinc phosphide followed by an anticoagulant--should be used.

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Table 3. Intake of anticoagulants (g/1QQ g body weight), mortality and time to death of Rattus rattus which had first consumed different dosages of zinc phosphide during one day of exposure.

	0.005% brodifacoum			0.025% coumatetralyl			0.025% warfarin		
Zinc phosphide intake (mg/kg)	Intake g/100 g	Mortality	Mean days to death	Intake g/100 g	Mortality	Mean days to death	Intake g/100 g	Mortality	Mean days to death
20	8.48 ± 1.42	5/5	4.5	8.31 ± 1.98	5/5	6.5	8.75 ± 1.06	5/5	12.5
29	8.21 ± 1.3	5/5	4.5	7.98 ± 1.3	5/5	6.5	8.83 ± 0.98	5/5	12.2
36	8.94 ± 1.48	5/5	4.0	7.23 ± 1.47	5/5	6.2	7.49 ± 1.02	5/5	11.5
45	7.61 ± 1.18	5/5	3.7	7.09 ± 0.98	5/5	5.5	7.28 ± 1.8	5/5	11.2
47	7.88 ± 1.83	5/5	3.5	7.46 ± 1.84	5/5	5.2	7.76 ± 0.89	5/5	11.0
57	8.10 ± 1.62	6/6	2.6	8.43 ± 1.73	5/5	4.3	8.41 ± 1.16	5/5	10.2
58	7.95 ± 1.8	6/6	2.4	8.49 ± 1.65	5/5	4.1	7.87 ± 1.32	5/5	9.8
60	8.21 ± 1.5	6/6	2.3	8.5 ± 1.8	5/5	4.0	8.6 ± 2.0	5/5	9.6