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STUDIES WITH ZINC PHOSPHIDE ON *BANDICOTA BENGALENSIS* (GRAY) AND *RATTUS RATTUS* (LINNAEUS) IN BANGLADESH

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Abstract : Toxicity studies of Zinc phosphide on *Bandicota bengalensis* (Gray) showed LD_{50} for males and females to be 28.3 and 23.8 mg/kg, and 25.9 mg/kg for combined sexes. Bioassay tests indicated that a 2% bait should produce satisfactory control of the species in fields. The species was less prone to bait shyness than *Rattus rattus* (L). Grease formulation experiments did not give encouraging results ; the rats responded to the treated sticks by plugging the burrows.

INTRODUCTION

The acute rodenticide, zinc phosphide (Zn_3P_2) has been used worldwide for controlling urban and field rodents. A concise review of the development and evaluation of zinc phosphide was presented by Hood (1972), and Tongtavee (1978) discussed its use for field rodents. In South Asia, Barnett & Prakash (1975) reported that zinc phosphide was used at concentrations of 1 to 5% to control rodents such as the lesser bandicoot rat *Bandicota bengalensis* (Gray) and the short-tailed mole rat *Nesokia indica* (Gray).

The relative paucity of zinc phosphide toxicity information on the lesser bandicoot rat is evident and contrasting. Srivastava *et al.* (1971), for example, reported the LD_{50} for zinc phosphide in the lesser bandicoot rat as 2.5 mg/kg while Htun & Brooks (1979) observed a value of 25.0 mg/kg. Since zinc phosphide is the only registered rodenticide in Bangladesh and conflicting published reports on the chemical exist, comparative studies were initiated in Bangladesh.

METHODS

LD_{50} Determination

The LD_{50}, or lethal dosage of a toxicant required to kill 50% of the test population, is expressed in milligrams of chemical per kilogram of body weight (mg/kg). This figure enables researchers to categorize the toxicity level of a rodenticide, which provides insight into effective dose levels for animals and safety factors to consider for personnel involved with the experiments or control.

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The LD_{50} was determined according to the procedures described by Thompson (1947) and Thompson & Weil (1952). Lesser bandicoot rats and black rats *Rattus rattus* (Linnaeus) were live-trapped in the C.S.D. Godown, Tejgaon, Dacca. Potatoes, bananas, and mangoes were used as bait. Captured animals were transported to the BARI, Vertebrate Pest Division laboratory at Joydevpur. Rats were dusted for ectoparasites with **Purina Dog Powder** containing 0.1% pyrethrine. Rats were weighed to the nearest gram (g), sex determined, and the reproductive condition of each recorded. Animals were retained in individual cages, 42 × 24 × 17 cm for a minimum of 1 week before initiating tests. Abnormally large or small animals, or obviously pregnant individuals were omitted from the experiment.

Technical grade zinc phosphide (94% active ingredient) was provided by the Denver Wildlife Research Center, Denver Colorado, U.S.A. The compound was mixed in 5-ml glass beakers and suspended in corn oil at concentrations of 8 and 2 mg/ml. Zinc phosphide was administered orally with a ball-tipped 22-gauge needle.

Food was removed from the animal cages a minimum of 4 hours before administering the chemical. Four dose levels of zinc phosphide were given to rats. Four male and four female rats were tested at each of the levels, 5, 10, 20, and 40 mg/kg. The animals were observed for a 5-day period after administration of the chemical.

The general LD_{50} formula was used (Thompson & Weil 1952).

$$\log m = \log Da + d \times (f - 1)$$

where log m is the logarithm of the LD_{50}, log Da is the logarithm of the lowest dosage level, d is the log constant between dosages, and f is a function for the estimation of median effect dose.

The 95% confidence limits were obtained by:

$$\log m \pm 2d \times \delta f,$$

where δ is a function calculated by Thompson & Weil (1952).

Feeding trials

"Choice" and "no-choice" feeding experiments were conducted using zinc phosphide and plain baits. In the choice test described by Hum & Brooks (1979) two food cups were provided to individually caged animals. One contained plain wheat flour and the other 1 or 2% zinc phosphide-treated flour. The position of the cups was changed daily to avoid possible bias of position preference (Brooks, personal comm.). Twenty grams of treated and untreated food was provided daily and consumption was measured to the nearest 0.1 g.

In the no-choice test, zinc phosphide-treated flour was offered at concentrations of 1 and 2% by weight. Food consumption was recorded daily and weighed to the nearest 0.1 g.

Efficacy of grease treated with Zinc Phosphide

Most rats, including *B. bengalensis*, are meticulous groomers. If dirt or foreign substances come in contact with the hairs, the rat will spend much time removing the material and keeping clean. Historically, many rodent species develop a shyness to zinc phosphide baits. If the rats ingest a sublethal dose, the discomfort is associated with the scent of the rodenticide. Rats will then shy away from treated baits.

Since zinc phosphide is an acute rodenticide and relatively inexpensive, it was decided to examine alternate approaches to having the animal ingest the compound. In the Philippines (Sanchez 1977) and Hawaii, U.S.A. (Fellows 1979) trials on *Rattus* spp. using grease have shown the potential of the technique to be quite good. The rodenticide was mixed with commercial axle grease and when a rat came in contact with the grease applied along artificial runways or burrows, the rat groomed itself and ingested the toxicant.

Laboratory trials were conducted using 2 and 7% zinc phosphide-treated grease formulations. Individually caged animals were dabbed with about 0.5 g of grease along the flanks, back or head. The animals were observed for 5 days and mortality was recorded.

The applicability of this technique was tested under field conditions in April 1979, before the wheat harvest. Zinc phosphide-treated grease was applied to 15 cm long × 0.5 cm diameter bamboo sticks. These were positioned in the entrances of active lesser bandicoot rat burrows. Sticks with grease were placed in one of three positions: horizontally, vertically, or at an angle. The objective was to have the rat come in contact with the grease when vacating the burrow, thus, offering the possibility of ingestion of the zinc phosphide during grooming bouts.

Bioassay of Zinc Phosphide field bait

Zinc phosphide-treated bait obtained from the Vertebrate Pest Control Centre, Karachi, Pakistan, was laboratory tested. The bait consisted of 48% cracked rice, 48% wheat flour, 2% oil, and 2% zinc phosphide. The technique for preparation is described by Smythe & Khan (1978). The approximate 2 × 2-cm baits were offered to individually caged *B. bengalensis* and *R. rattus* and mortality was observed.

RESULTS

LD_{50} Determination

Results of the LD_{50} test with zinc phosphide given by oral intubation are given in Table 1. The LD_{50} for male and female *B. bengalensis* was 28.3 and 23.8 mg/kg, respectively. In combining data for both sexes, the LD_{50} value

was 25.9 mg/kg. In both sexes, no mortality was observed at the 5 and 10 mg/kg dose levels. At 20 mg/kg only one female died while no male deaths were recorded. All rats dosed at 40 mg/kg died within 26 hours. One male died 6 hours after administration of zinc phosphide.

Table 1. Zinc phosphide LD_{50} determination in the lesser bandicoot rat (*B. bengalensis*) from Dacca, Bangladesh.

Dosage level		No. dead rats/No. tested Males	Females	Combined Sexes
5 mg/kg		0/4	0/4	
10 mg/kg		0/4	0/4	
20 mg/kg		0/4	1/4	
40 mg/kg		4/4	4/4	
LD_{50} mg/kg		28.3	23.8	25.9
95% confidence limits	upper	a	33.6	30.8
	lower		16.8	21.8

[a] Not possible to determine confidence limits with these data.

Feeding Trials

Zinc phosphide-treated wheat flour was provided to lesser bandicoot rats at concentrations of 1 and 2% to obtain an acceptable concentration for field testing. The results of the choice and no-choice tests are summarized in Table 2. In the choice test at a 1% concentration, 90% of the rats died within 3 days. The survivor consumed 71.1 mg/kg zinc phosphide or almost 3 LD_{50}'s. Bait with 2% zinc phosphide produced 100% mortality in the rats.

Table 2. Results of choice and no-choice tests of wheat flour treated with zinc phosphide offered to lesser bandicoot rats in the laboratory.

Concentration	Sex	Mean body weight (g)	Mortality	Mean bait intake (g) Zn_3P_2	Plain	Mean and range in mg/kg of Zn_3P_2 eaten by rats
Choice test						
1%	F	169.8	5/5	1.2	9.2	75.7 (38.4-124)
	M	221.5	4/5	1.6	18.0	65.6 (24.8-155.8)
2%	F	202.5	5/5	0.58	3.65	24.8 (7.9-86.3)
	M	214.5	5/5	0.1	4.02	48.3 (14.9-83.3)
No-choice test						
1%	F (preg)	181.3	7/7	2.25		
	F (non-preg)	188.0	3/3	2.1		90.7 (48.5-114.9)
2%	M	202.2	5/5	1.9		87.1 (51.0-131.6)
	F	190.7	5/5	1.0		54.0 (43.2-120.3)

In the no-choice test, all rats ate some treated food daily until death. Mortality at both the 1 and 2% levels was 100%.

Grease Formulations

The lesser bandicoot rat was observed to be a careful groomer, removing baits of dirt and foreign objects from its hairs. Mortality in the animals in which a 2 and 7% grease formulation was applied, was 2/5 and 3/5, respectively, 5 days after application.

From 12 to 22 April 1979, bamboo sticks with a 5% zinc phosphide-grease formulation were positioned at the entrance of lesser bandicoot active burrows in mature wheatfields. A total of 228 bamboo sticks were placed in burrow entrances at one of three positions : horizontal, vertical, and diagonal. Table 3 summarizes the results.

Table 3. Field trial examining the feasibility of a grease-zinc phosphide formulation applied to bamboo sticks positioned in burrow entrances.

Stick Position	No. Placed	No. untouched	No. with grease rubbed off	No. holes plugged	% untouched with plugs
Vertical	96	58	38	15	26
Horizontal	85	79	6	36	46
Angle	47	45	2	27	60

Often when lesser bandicoot rats detected a foreign object near the burrow entrance, the animal did not exit. The position of the stick showed whether or not a rat vacated the burrow. When a rat detected the stick, rather than leave the burrow through that entrance, it sometimes plugged the entrance with dirt from the inside. The plug was cylindrical in shape, about 15 cm long and 7 cm in diameter. The plug consisted of packed earth, but in sandy soils wheat stems and leaf blades were used to help compact the plug. Treated sticks placed vertically resulted in fewer burrow entrances being plugged.

Zinc Phosphide field bait

A prepared 2% zinc phosphide bait was provided to *B. bengalensis* and *R. rattus* in test cages. The results are given in Table 4. In both a

Table 4. Results of the zinc phosphide prepared bait test on *B. bengalensis* and *R. rattus*. (The bait was provided by the Vertebrate Pest Centre in Karachi, Pakistan).

	Sex	Observed mortality
Choice test		
B. bengalensis	M	2/4
	F	4/4
R. rattus	M	1/3
	F	3/5
No-choice test		
B. bengalensis	M	3/3
	F	2/2
R. rattus	M	0/3
	F	0/3

choice and no-choice test, 100% mortality was observed in the lesser bandicoot rat, while the black rat displayed shyness.

DISCUSSION

Toxicity studies using zinc phosphide have been completed on numerous rodent species. LD_{50} values for some Asian Muridae are given in Table 5. Results of the LD_{50} determination for the lesser bandicoot rat (25.9 mg/kg) in this study supports the recent findings of Htun & Brooks (1979) in Burma in which an LD_{50} was calculated to be 25.0 mg/kg.

Table 5. Oral toxicity of zinc phosphide in Asian Muridae.

Species	LD_{50} (mg/kg)	Reference
Norway rat *R. norvegicus* (Berkenhout)	40.5	Rudd & Genelly 1956
Black rat *R. rattus* (Linnaeus)	21.3	Hilton & Robinson 1972
Black rat *R. r. mindanensis*	28.0	West *et al.* 1973
Polynesian rat *R. exulans* (Peale)	23.1	Hilton & Robinson 1972
Ricefield rat *R. argentiventer* (Robinson & Kloss)	35.0	Hood 1972
Lesser bandicoot rat *B. bengalensis* (Gray)	2.5	Srivastava *et al.* 1968
Lesser bandicoot rat	25.0	Htun & Brooks 1979
Lesser bandicoot rat	25.9	This study

Bioassay tests indicated that a 2% zinc phosphide bait should produce satisfactory control of lesser bandicoot rats in fields. Htun & Brooks (1979) suggested that a 2.5% zinc phosphide bait is probably better, whereas Smythe & Khan (1978) advocated the use of a 2% bait for field use.

The present findings indicate that in the use of zinc phosphide, the lesser bandicoot rat is less prone to bait shyness as compared to the black rat. More research into a good formulation is required before large-scale field trials are attempted. The rice-wheat-oil formulation developed in Pakistan has great potential for field application in Bangladesh.

Results of the grease formulation experiment indicated that the use of such a technique for field control of lesser bandicoot rats may not be desirable. The rats responded to the treated sticks by plugging burrows. In addition no dead rats were found in the study area. Rats which removed grease when leaving burrows apparently ingested sublethal doses. If most grooming was done after returning to the burrow, much of the grease was probably rubbed off as the rat maneuvered through the tunnel.

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