

RELATIONSHIPS OF COSTS TO ORAL TOXICITIES OF FIVE RODENTICIDES
AVAILABLE COMMERCIALY IN THE PHILIPPINES

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ABSTRACT

Two laboratory trials were conducted in which adult *Rattus rattus mindanensis* were fed polished rice containing anticoagulant rodenticides from commercial outlets in the Philippines, and mortalities recorded for at least 30 days after treatment. The derivatives of coumatrin cost less (P<0.096 per mortality) than derivatives of indandione (P<0.155 per mortality), and cost was closely related (P<0.0007) to animal weight, consumption and days to death. Additional studies are required to determine performance of the compounds in the field.

INTRODUCTION

Since 1974, the Philippine Government has recommended anticoagulant rodenticides for damage reduction as part of its national rice (Masagana-99) and corn (Masaganang Maisan) production programs, and use of these compounds by farmers is increasing. Several chemical types, under a variety of brand names and formulations, are available commercially, but little is known about the relationships of costs to toxicities of the compounds despite frequent requests for such information from farmers.

Sanchez *et al.* (1972) provided a list of anticoagulants and other rodenticides available locally, and compared costs for preparation of one kilogram of bait, but did not relate cost to toxicities. Kuehnert and Coronel (1977) recently compared costs of five com-

mercial products to their toxic activities, but they presented no statistical analysis of their results and we felt that some of their conclusions exceeded the nature and sensitivity of their trials.

We report here the findings from two trials in which the common crop pest, *Rattus rattus mindanensis*, was fed polished rice containing one of five anticoagulant products obtained from commercial outlets; mortalities were recorded for at least 30 days after treatment. The initial trial was repeated using rats collected with the original sample but held in the laboratory for an additional 38 days before treatment. The experiment was designed to allow statistical comparisons of results that served as bases for our conclusions.

MATERIALS AND METHODS

Five common formulations were purchased from local dealers for the trials and costs recorded. The products were: Racumin^{1/} (0.5% active ingredient, 3-(tetra-*l*yl)-4-hydroxycoumarin), Ratoxin (1.0%, 3-(acetonyl-benzyl)-4-hydroxycoumarin), and Tomorin (1.0% 3-(acetonyl-4-chlorobenzyl)-4-hydroxycoumarin) representing derivatives of coumarin; and Diphacin (0.1%, 2-diphenyl-1, 3-indandione) and Liphadione (0.25%, 2-[*p*-chlorophenyl] phenylacetyl-1, 3-indandione) representing derivatives of indandione. The rodenticides were mixed with polished rice to provide bait with the following concentrations of toxicant: Racumin, 0.0375%; Ratoxin, 0.025%; Tomorin, 0.0278%; Diphacin, 0.0025%; and Liphadione, 0.0049%.

Rats were collected from ricefields in San Isidro, Nueva Ecija, and brought into the laboratory. They were grouped in cages by sex and maintained with "creep pellets" (a local feed for domestic animals) and water *ad libitum* for one to three months prior to the trials. Non-gravid adult rats that appeared healthy were used for the trials.

One week before each trial, test animals were selected, weighed, placed in individual cages (17 cm x 24.5 cm x 17.5 cm), and fed polished rice and water *ad libitum*. Twenty rats were assigned randomly to each of the five compounds and to a control group (fed polished rice with no toxicant). For treatments, each rat was given about 15 g daily of the formulations to which it was assigned with no alternative food. Individual consumption was measured each day by weighing unconsumed food (including spillage) and subtracting from the total provided the prior evening. Daily records were also kept on mortalities; the trial was continued until all animals had died. Actual costs (per mortality) were calculated, based on the total consumption of each rat and the price (per kg) of the prepared baits.

Days to death, total consumption, average daily consumption, animal weight, and costs per mortality were compared between trials and between treatments using one-way analysis of variance for a completely randomized design; relationships between variables were determined by simple regression analyses. The best equations for predicting actual costs were determined for up to three variables using a stepwise regression procedure.

^{1/} Use of trade names does not imply endorsement or recommendation of specific chemicals or commercial products by the Philippine or the U.S. government.

RESULTS AND DISCUSSION

Total consumption, daily consumption, and cost of bait (per mortality were significantly ($P < 0.05$) higher in the second trial than in the first, and fewer days were required for mortality ($P < 0.05$; Table 1). Animal weights were also greater ($P < 0.05$) in the second trial because the rats had been maintained in the laboratory for an additional 38 days before treatment. The relationships (described below) of increased animal size with such variables as daily and total consumption appear to have been the main cause of the higher costs per mortality during the second trial.

Animals in the control groups weighed about the same as rats in the other groups, but consumed (daily and totally) more ($P < 0.05$) bait. We cannot determine the causes from this study, but four of the animals (one each being fed Diphacin, Liphadione, Racumin and Tomorin) ate 3 g or less of the prepared bait during the entire periods of exposures and died between five and 11 days after treatment. In part because of this bias, we caution against acceptance of field recommendations for use of specific compounds when the recommendations are based solely upon the results of no-choice, laboratory trials such as ours or the study of Kuehnert and Coronel (1977). In the field, alternative foods are available to rats if they develop aversion to treated baits.

Cost of bait per mortality was greater ($P < 0.05$) for derivatives of indandione than for derivatives of coumarin; differences between compounds within these chemical types were small and not significant. Costs of bait per mortality were highly related ($P < 0.0007$) to animal weight, daily consumption, total consumption, and days to death. With a one-variable model, cost ($\$/mortality$; Y) was most closely correlated ($r^2 = 0.86$; $P < 0.0001$) with total consumption (X in grams; $Y = 0.00322 X - 0.0025$). The correlation was not significantly improved by using a two- or three- variable model.

We conclude that, under laboratory conditions where rats are given baits without alternative food and at current market costs of rodenticides, the derivatives of coumarin cost less per mortality than those of indandione, and that cost is closely related to animal weight, consumption, and days to death. In our study, no single compound appeared significantly less expensive than the rest, and we question the recommendation of Kuehnert and Coronel (1977) that "attention should be paid to Liphadione due to its highest effectiveness followed by Racumin, which is with good peculiarity and economical characteristics." Additional studies are required to determine the relative performances of anticoagulants in the field.

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Table 1. Performance of five anticoagulant rodenticides during two no-choice feeding trials. The rodenticides, all available commercially in the Philippines, were mixed with polished rice to the manufacturers' recommendations. Twenty adult rats per treatment were used for each trial. Rats were all taken from the same population; the second trial followed the first by 38 days.

Treatment ^{1/}	Cost of prepared bait (P/kg) ^{2/}	Body weight (Mean gram)			Total consumption (Mean gram)			Daily consumption (Mean gram)			Days to death (Mean no.)			Cost of bait (Mean P per mortality)		
		Trial 1	Trial 2	Trials 1 & 2	Trial 1	Trial 2	Trials 1 & 2	Trial 1	Trial 2	Trials 1 & 2	Trial 1	Trial 2	Trials 1 & 2	Trial 1	Trial 2	Trials 1 & 2
Diphacin	3.25	157	147	151	44.9	47.4	46.2 ^a	4.24	5.02	4.63 ^a	10.6	9.4	10.0	0.155	0.164	0.159 ^a
Liphadione	4.25	133	161	148	29.7	41.6	35.6 ^{a,c}	3.73	4.74	4.06 ^a	9.8	8.4	9.2	0.126	0.177	0.151 ^a
Racumin	2.87	138	161	150	28.8	36.9	32.8 ^{a,c}	3.09	5.63	4.36 ^a	9.8	7.1	8.4	0.083	0.166	0.094 ^b
Ratoxin	2.52	145	158	152	39.0	42.6	40.8 ^{a,c}	4.01	4.65	4.35 ^a	10.2	9.7	10.0	0.098	0.107	0.103 ^b
Tomozin	2.60	130	155	142	30.2	39.2	34.7 ^{a,c}	3.29	5.07	4.18 ^a	9.2	8.2	8.7	0.080	0.104	0.092 ^b
Control ^{3/}	<u>2.10</u>	<u>145</u>	<u>162</u>	<u>154</u>	<u>127</u>	<u>146</u>	<u>136.5^b</u>	<u>6.34</u>	<u>7.62</u>	<u>6.98^b</u>	-	-	-	-	-	-
All Groups ^{4/}	2.98	142	158	150	49.9	59.0	54.4	4.06	5.46	4.76	9.9	8.6	9.2	0.108	0.132	0.120

1/ Means for Trials 1 & 2 were compared with Duncan's Multiple Range Test following analysis of variance; means in columns with different letters are significantly different ($P < 0.05$).

2/ One peso (P) = ca. U.S. \$0.14

3/ Total and daily consumption are based on the first 20 days of each trial.

4/ Treatment means for all groups were compared between trials by analysis of variance for each variable; all were significantly different ($P < 0.05$).

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