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Laboratory and field evaluation of pyriminyl as a poison for *Rattus norvegicus*

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SUMMARY

Laboratory tests indicated that the optimum concentration for pyriminyl in rat baits was between 1% and 3%. In field trials in which 0·5% pyriminyl (the concentration in commercial use) was compared with 2·5% zinc phosphide for the control of rats on farms, the pyriminyl treatments were significantly less effective than the zinc phosphide even when the poisoned baits were left down for 7 days instead of 1 day after prebaiting. Both poisons were as effective in medium oatmeal bait as they were in medium oatmeal containing 5% corn oil and 5% sugar.

INTRODUCTION

The compound 1-(3-pyridyl methyl)-3-4-nitrophenyl) urea, developed by the Rohm and Haas Co., was first marketed in the U.S.A. in 1975 as an acute poison for the control of *Rattus norvegicus*, *R. rattus* and *Mus musculus*. Since then it has been used throughout the world and is now apparently the second biggest selling rodenticide in the U.S.A. (Peardon, 1978). Various trade names have been assigned to the compound, and formulations of it, including RH 787, Vacor and DLP 787. Pyrinuron is the common chemical name currently listed by FAO and WHO.

Howard & Marsh (1974) predicted that pyriminyl would be one of the most significant developments in rodent control since the introduction of warfarin. Marsh & Howard (1975) stated that the compound was a relatively slow acting but acute poison, selective to the target species, and that rodents continued to feed on poisoned baits after they had eaten a sub-lethal dose. However, the poison appears to be toxic to man; seven human deaths in Korea were attributed to pyriminyl (Marsh, 1975) while of the 15 known cases of ingestion by human adults in the U.S.A., four subjects died and the remaining eleven showed sustained insulin-dependent diabetes mellitus (Prosser & Karam, 1978). To increase safety, therefore, the manufacturers reduced the concentration of the poison in their rat control products from 2% to 0·5% (Peardon, 1978). Poison baiting with either of these concentrations of pyriminyl for 3–8 days has been reported to be effective against a range of murine rodents. Between 70% and 96% of *R. norvegicus* were

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estimated by census baiting to have been killed using 2% pyriminyl in field trials in Scotland (Ramkrisnan & Suchak, 1975) and 97·8% using 0·5% pyriminyl (Peardon, 1978). However, the brevity of these reports and the absence of data from comparable control treatments with established rodenticides make it difficult to judge how well pyriminyl compares with other acute rodenticides under similar conditions.

This paper gives the results of laboratory evaluation tests and comparative field trials that were carried out by this laboratory under limited clearance granted by the Pesticides Safety Precautions Scheme.

METHODS

Laboratory tests

Tests were carried out with male Wistar-derived laboratory rats and also with wild rats caught either in the warfarin-resistance area on the Anglo-Welsh border or in a refuse destructor in the West Midland Metropolitan County.

The oral toxicity of pyriminyl was determined by stomach-tube administration to laboratory animals grouped 5 to a cage. The compound was finely ground in a mortar and suspended in a 5% solution of powdered gum acacia. Feeding experiments were carried out with singly caged laboratory and wild rats. The bait for these was made up of 90% pinhead (coarse) oatmeal, 5% corn oil and 5% wholemeal flour in which the active ingredient was dispersed. In both the 'no-choice' and 'choice' feeding tests, mortality and the amounts of bait eaten were recorded.

Field trials

The field trials were conducted against warfarin-resistant rat infestations in farm buildings in the counties of Powys and Salop.

Infestations on 12 farms were first census baited with dry whole wheat for 5 days and prebaited for a further 5 days with either plain medium grade oatmeal (six infestations) or medium oatmeal to which 5% by weight each of corn oil and fine-grained sugar had been added. The latter bait formulation is similar to that used by the manufacturers in ready-made poisoned baits for rat control (Rohm & Haas Co., personal communication).

The prebaits were then removed and similar baits containing either 0·5% pyriminyl (six infestations) or 2·5% zinc phosphide were laid for 24 h. The choice of bait and poison for each treatment was decided at random so that three infestations were treated with each of the four poison and bait formulations (Table 5).

Starting 2 days after poison baiting, each infestation was again census baited with dry whole wheat for 5 days.

The same pair of operators carried out the programme of census and treatment baiting by working together on three farms at a time. On each farm they recorded the total weight of census wheat and prebait eaten daily by rats, but because the takes of poisoned bait were too small to weigh accurately, they also recorded the number of bait points at which poisoned bait had been eaten. To facilitate bait weighing and recording, all baits were laid on cardboard or wooden baiting trays.

The maximum weights of census wheat eaten in a day by rats were used as indexes of the pre-treatment and post-treatment infestation sizes. The differences between the pre-treatment and post-treatment indexes were converted to percentages of the pre-treatment indexes (percentage mortality) for analysis. The assessment methods differed from those formerly recommended (Rennison, 1975, 1976) for two reasons. First, as the two baits used may not have been equally palatable, it was not possible to use the prebait takes as indexes of pre-treatment infestation size. Second, it has been shown that indexes of percentage mortality derived from census takes are marginally more accurate than indexes derived from covariance adjusted mean post-treatment census bait takes (Huson, 1980).

To test the assertion that pyriminyl does not cause bait shyness (Marsh & Howard, 1975) and to see if the kill could therefore be improved by poison baiting for longer than 24 h, four other farm infestations were treated – one with each of the above four bait and poison formulations. The same methods were used as on the first 12 farms except that the pyriminyl and zinc phosphide poisoned baits were left down for 7 days.

RESULTS AND DISCUSSION

Laboratory tests

Oral toxicity

The results of the oral intubation tests with the laboratory strain of rat (Table 1) indicated an approximate acute oral LD 50 of 17·5 mg/kg. At the 100 mg/kg dose, symptoms of poisoning first appeared about 4 h after intubation while, at the 30 mg/kg dose it was 1 h later. In those cases observed, death followed within 1 h

Table 1. *Mortality of male laboratory rats after oral intubation tests with pyriminyl*

	Mean body weight (g)	Dose (mg/kg)	Mortality
Single dose	99	100	20/20
	91	30	5/5
	104	10	0/15
Four daily doses	99	10	7/15
	99	1	0/15

Table 2. *Results of feeding tests in which male laboratory rats were given a sole diet of pyriminyl in pinhead oatmeal and corn oil bait for 24 h*

Mean body weight (g)	Pyriminyl conc. (%)	Mortality	Lethal dose of active ingredient (mg/kg)		Survived dose of active ingredient (mg/kg)	
			Mean	Range	Mean	Range
116	3·0	5/5	274	165–420	—	—
108	0·3	5/5	89	71–108	—	—
170	0·03	0/5	—	—	40	37–41
164	0·003	0/5	—	—	4	4–5

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Table 3. *Results of feeding tests in which wild* R. norvegicus *were given a sole diet of pyriminyl in pinhead oatmeal/corn oil for* 24 *h*

Mean body weight (g)	Concentration (%)	Mortality	Mean bait intake/rat (g)		Lethal dose of active ingredient (mg/kg)		Survived dose of active ingredient (mg/kg)	
			Prebait	Poison	Mean	Range	Mean	Range
196	3·0	4/5	12·2	0·9	147	64–216	38	—
164	2·0	5/5	13·7	1·1	134	108–162	—	—
240	1·0	4/5	12·6	1·3	54	25–82	33	—
200	0·5	4/5	11·0	3·4	105	67–137	8	—

Table 4. *Bait consumption and mortality of wild* R. norvegicus *given a choice between pyriminyl poisoned and plain bait for* 48 *h*

Mean body weight (g)	Pyriminyl concentration (%)	Mortality	Mean daily bait intake/rat (g)		No. of animals preferring poisoned bait	Significance (P) of Student's t
			Poison	Plain		
205	3·0	9/10	1·4	3·3	4/10	NS
210	2·0	14/15	0·9	5·9	3/15	0·005
162	1·0	7/10	0·8	5·2	3/10	0·05
135	0·3	2/5	2·5	6·7	0/5	NS

(Bait consumption figures for first day only used in calculations in 4th, 5th and 7th columns)

of the onset of visible sickness and in all cases occurred within 24 h. With four daily doses there was an indication of a cumulative effect. At 10 mg/kg the mortality was 7/15; the first death occurred after the third dose and the other six between days 5 and 11.

'No-choice' feeding tests

Complete kills of laboratory rats were obtained after 1 day's exposure to poison at 3 % and 0·3 % (Table 2), all deaths occurring within 24 h. The average food intake per rat was 1·7 and 3·3 g respectively. There were no deaths at the lower concentrations. With wild rats, kills of 4/5 with the poison at 3 %, 1 % and 0·5 % were recorded but at 2 % all animals died. The figures for the mean bait intake (Table 3) show that, when prebait was replaced by poisoned bait, there was a marked drop in food consumption.

'Choice' feeding tests

The results of 'choice' feeding tests on wild rats (Table 4) were somewhat anomalous: at 2 % and 1 %, pyriminyl was significantly unpalatable ($P < 0{\cdot}05$) but at 3 % the difference in bait consumption was not significant. The largest kill (14/15) was obtained at the 2 % concentration, which was also the most unpalatable.

The laboratory results thus suggested that a concentration between 1 % and 3 % would be optimal in the field for the control of *R. norvegicus*.

Field trials

The absence of significantly large mean squares for baits, poisons or the baits × poisons interaction in the analysis of variance of the data in Table 5 indicated that both the poisons were equally effective overall and also in each of the two baits in which they were applied. On average, about 76·5 % of the target rats were killed in all treatments when the poisoned baits were laid for 24 h.

In the four additional treatments, in which the poisoned baits were left down for 7 days (Table 6), the baits contributed only insignificantly but the poisons significantly ($P < 0{\cdot}05$) to the variation in the results. The average kill with 0·5 % pyriminyl was 91·1 % and that with 2·5 % zinc phosphide was 97·8 %.

The 24 h poison baiting trial was inconclusive because very poor control (43·9 %) was achieved with zinc phosphide on one farm. Baiting with meal-based baits on that farm proved to be exceptionally difficult in competition with spilled meal and grain in a complex of old buildings that were being used to house grain silos, a grain mill and an egg battery unit. If this poor result is discounted and the other 11 percentages in Table 5 re-analysed, the mean square for baits remains insignificant but that for poisons becomes significantly large ($f = 25{\cdot}9$; $P < 0{\cdot}001$), the mean kill with 2·5 % zinc phosphide on five farms being 90·2 %, compared with 70·6 % with 0·5 % pyriminyl on the other six.

The average level of control obtained by baiting for 7 days with 0·5 % pyriminyl (90·1 %) was significantly better than the 70·6 % achieved by 24 h baiting ($t = 4{\cdot}67$; $P < 0{\cdot}01$). The control obtained with 2·5 % zinc phosphide (97·8 %),

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Table 5. *The estimated percentages of rats killed on 12 farms following 24 h poison baiting with either 0·5 % pyriminyl or 2·5 % zinc phosphide in oatmeal baits with or without added corn oil and sugar*

Baits	Poisons: Pyriminyl 0·5 %	Poisons: Zinc phosphide 2·5 %	Bait means
Medium oatmeal	64·3	79·6	
5 % corn oil	69·7	94·9	80·2
5 % sugar	78·5	94·3	
Mean	70·8	89·6	
Medium oatmeal	65·3	89·7	
	68·8	92·6	72·9
	76·9	43·9	
Mean	70·3	75·4	
Poison mean	70·6	82·5	76·5

Analysis of variance

Source of variance	D.F.	M.S.	*F*	*P*
Baits	1	162·1	0·7	NS
Poison	1	426·0	1·9	NS
Baits × poisons	1	140·8	0·6	NS
Residual error	8	227·0	—	

Table 6. *The results of prebaiting and then poison baiting rats on four farms for 7 days with either 0·5 % pyriminyl or 2·5 % zinc phosphide in medium oatmeal (MO) or medium oatmeal containing also 5 % corn oil and 5 % sugar (MO, CO, S)*

Poison	Bait	No. of poison bait takes recorded on day: 1	2	3	w/e 6	7		Estimated mortality (%)
0·5 % pyriminyl	MO, CO, S	16	1	2	2	5		91·3
	MO	11	4	1	4	4		90·9
	Total	27	5	3	6	9	Mean	91·1
2·5 % zinc phosphide	MO, CO, S	12	1	1	1	0		97·7
	MO	22	0	0	4	2		98·0
	Total	34	1	1	5	2	Mean	97·8

Analysis of variance of percentage mortality

Source of variance	D.F.	M.S.	*F*	*P*
Baits	1	0·0025	—	NS
Poisons	1	45·5625	371·9	< 0·05
Baits × poisons (error)	1	0·1225	—	—

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on the other hand, was not significantly better than either the 82·5 % obtained on six farms ($t = 1{\cdot}63$; $P < 0{\cdot}1$) or the 90·2 % obtained on five ($t = 1{\cdot}04$; $P < 0{\cdot}3$) by 24 h poison baiting. The significant improvement with pyriminyl but not zinc phosphide is explained by the fact that a much greater proportion of the pyriminyl bait takes occurred after the first 24 h of poison baiting. In all, 50 takes of pyriminyl poisoned bait and 43 takes of zinc phosphide poisoned bait were recorded during the 7 days (Table 6); 23 of the pyriminyl takes but only 9 of the zinc phosphide takes occurred after the first 24 h ($t = 2{\cdot}54$; $P < 0{\cdot}02$).

CONCLUSIONS

The conclusion drawn from the laboratory screening, that between 1 % and 3 % pyriminyl would be as effective as 2·5 % zinc phosphide in rat bait, has generally been borne out by the field trials. The new poison was less effective than 2·5 % zinc phosphide when used at 0·5 %, the concentration in some current commercial formulations of pyriminyl, and so may be as effective as 2·5 % zinc phosphide if used at 1 % or a higher concentration. However, results published by Ramkrisnan & Suchak (1975) and Peardon (1978) suggest that the use of higher concentrations in unlikely to result in better control, while the risk of poisoning to humans would clearly be greatly increased.

Pyriminyl is reported to be much less toxic than zinc phosphide to a wide range of non-human animals (Dubock & Kaukeinen, 1978) and so may be safer to use in rat baits that have to be left down for several days in areas where non-target animals are at risk. However, the level of control that will be achieved is unlikely to be better than could be achieved by a single application of bait containing 2·5 % zinc phosphide.

Although there was some indication of cumulative toxicity in the laboratory tests, pyriminyl showed insufficient chronic activity to warrant field trials as a chronic poison. Pyriminyl is slower acting than zinc phosphide but is still essentially an acute poison and so, like zinc phosphide, will probably give the best results when applied in bait after a period of prebaiting.

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