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Field trials of the rodenticide gophacide against wild house mice (*Mus musculus* L.)*

BY F. P. ROWE, T. SWINNEY AND A. BRADFIELD

Pest Infestation Control Laboratory, Ministry of Agriculture, Fisheries and Food, Hook Rise South, Tolworth, Surbiton, Surrey

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SUMMARY

The acute rodenticide gophacide was tested against urban infestations of the house mouse (*Mus musculus* L.) and treatment success was assessed from the results of census baitings conducted before and after each treatment. Seven of eight populations of mice living in premises where alternative food supplies were limited were successfully controlled when medium oatmeal bait containing gophacide at 0·1 % was laid directly for 4 days. In further treatments against mice inhabiting more complex environments and having greater access to other foods, the performance of gophacide at 0·1 % and at 0·25 % in a wholemeal flour/pinhead oatmeal/corn oil bait was compared with that of zinc phosphide at 3·0 % in the same bait-base. The poison treatments were conducted for 1 or 4 days and always after 3 days pre-baiting. Treatment success varied considerably irrespective of the type of treatment or of the poison used. In general, however, gophacide proved to be as effective as zinc phosphide for the control of mice.

INTRODUCTION

In Britain it has become increasingly difficult during the past decade to satisfactorily control the house mouse (*Mus musculus* L.) with warfarin [3-(α-acetyl-benzyl)-4-hydroxycoumarin] or any other available chronic anticoagulant. Undoubtedly this difficulty, arising from the phenomenon of anticoagulant resistance (Rowe & Redfern, 1965), has been the major cause of the marked increase in the numbers of mouse infestations reported to local authorities in recent years (Ministry of Agriculture, Fisheries and Food, 1971; Shenker & Farrell, 1969). It has also highlighted the need for alternative effective rodenticides of both the acute (single-dose, quick-acting) and chronic kinds for use against *M. musculus*.

One compound of the acute kind that has been examined recently in the laboratory (Redfern, Greaves & Tinworth, 1975) is gophacide, 0,0-bis(*p*-chlorophenyl) acetimidoylphosphoramidothioate. The results of gophacide treatments carried out against free-living mice are presented below.

METHODS

In the field trials of gophacide the compound was applied either directly in bait or after pre-baiting.

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Direct poisoning

With minor exceptions the procedure adopted in eight direct poison treatments was as follows: (1) pre-treatment census (days 1–5), (2) direct poison treatment (days 8–12) and (3) post-treatment census (days 22–26). On day 1 a thorough inspection was made of each premises and small cardboard or plastic trays each containing 200 wheat grains were distributed 1·5–2 m. apart throughout the infested area. At 24 hr. intervals over the next 4 days, the surplus grains were removed for counting and the trays replenished with a further 200 grains. The trays were removed at the end of the census period and the poison treatment was begun 3 days later.

The poison bait was prepared by adding gophacide at 0·1 % to medium oatmeal containing 0·05 % of a dye, chlorazol sky blue. The same number of poison baits as census baits was laid but the poison baits were distributed at sites different from those chosen for censusing and placed either in small open trays (treatments 1–5) or in small wooden enclosed containers (treatments 6–8). Approximately 7 g. amounts of poison bait were laid at each point and examined daily during the 4-day treatment period.

A second census was conducted 10 days after poisoning, the census trays being laid at the sites chosen for the pre-treatment censusing. In this, the post-treatment censusing, 100 wheat grains were placed daily in each tray and the numbers remaining were recorded daily for 4 days. Additionally, small patches of basic slag were laid at strategic points in the treated area; these were examined daily for footprints and smoothed over when necessary.

Poisoning after pre-baiting

In further trials the performance of gophacide at either 0·1 % or 0·25 % was compared with that of zinc phosphide at 3·0 % in treatments carried out after pre-baiting. In each treatment poison bait was applied for 1 or 4 days after 3 days pre-baiting. In all, 18 treatments were conducted, the premises used for the six different types of treatment being chosen at random from those available. The pre-bait and carrier used for the poison were the same as those employed by Redfern, Greaves & Tinworth (1975) in their laboratory screening tests (wholemeal flour (5 %), corn oil (5 %) and pinhead oatmeal (to 100 %)) except for the addition of 0·05 % chlorazol sky blue.

The percentage success of each poison treatment was calculated from the total amount of plain bait (canary seed, *Phalaris canariensis*) consumed by mice on 4 consecutive days of pre- and post-treatment censusings. In each censusing, bait was laid on open trays which were closely distributed in the infested area. The same sites were chosen for the pre- and post-censusings but the pre-bait, though laid in the same number of trays, was put down at different sites. Pre-baiting was begun 7 days after the end of the pre-treatment censusing and the post-treatment censusing was carried out 10 days and 7 days after the end of the 1-day and 4-day poison treatment respectively – on the assumption that most of the mice would have eaten the poison during the first 24 h.

Table 1. *Results of direct treatments against mice using gophacide at 0·1 % in medium oatmeal*

Treatment no.	Pre-treatment census: nos. of wheat grains taken, Day 1	2	3	4	No. of visits to poison baits, Day 1	2	3	4	Post-treatment census: nos. of wheat grains taken, Day 1	2	3	4
1	29	138	37	108	5	2	0	0	0	0	0	0
2	40	75	28	66	2	2	0	0	0	0	0	0
3	568	487	504	451	—	—	—	—	0	0	0	0
4	324	318	291	282	15	0	0	0	0	0	0	0
5	122	153	155	139	20	13	0	0	0	0	33	27
6	254	351	500	504	22	12	2	2	0	0	0	0
7	313	297	227	207	6	7	2	0	0	0	0	0
8	421	436	389	337	7	5	2	0	0	0	0	0
Totals	2071	2255	2131	2094	77	41	6	2	0	0	33	27

RESULTS AND DISCUSSION

The number of wheat grains taken daily by mice at the pre- and post-censusings in each of the direct gophacide treatments is shown in Table 1 and with one exception (treatment 3), the numbers of poison baits visited on each day of the treatment period. In only one of the post-treatment censusings (treatment 5) were wheat grains taken and footprints found in the basic slag patches to show that the treatments had not been completely successful.

The results of the 1- and 4-day treatments in which pre-baiting was followed by gophacide or zinc phosphide are shown in Table 2; the amounts of census bait and pre-bait eaten daily are given together with the numbers of poison baits visited by mice.

In the case of gophacide, control in these treatments was inferior to that obtained in the direct poison treatments. Seven of the eight mouse infestations treated directly with gophacide bait were eradicated but only 4 of the 12 treated after pre-baiting. It is considered unlikely that this differential success can be attributed to the use of different bait-bases in the two series of trials. This follows from pilot treatments with gophacide using both bait-bases, that were carried out before the field trials were begun. Two populations of wild mice were first established in similar rooms (floor area 25 $m.^2$) and provided with nesting material and a central feeding station containing powdered laboratory diet 41B. Seven days later the mice were additionally offered either a medium oatmeal or a wholemeal flour/pinhead oatmeal/corn oil bait containing 0·1 % gophacide placed at six points around the perimeter of each room. Similar mortalities were obtained with both gophacide baits – 13/15 after 12 days (range of days to death 1–5) and 11/12 after 7 days (range of days to death 1–2) respectively.

A more probable explanation of the relative difference in effectiveness found in the trials is based on the results of earlier work on mice by Southern (1954). After carrying out various trials of acute poisoning methods, he concluded that direct poisoning was only likely to be successful in treating mice that were living in

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Table 2. *Results of pre-baiting/poison treatments against mice using gophacide and zinc phosphide*

Treatment Type	No.	Pre-treatment census: consumption of canary seed (g.) Day 1	2	3	4	Poison treatment: Consumption of pre-bait (g.) Day 1	2	3	Poison treatment: No. of visits to poison baits Day 1	2–4	Post-treatment census: consumption of canary seed (g.) Day 1	2	3	4	Estimated success (%)
0·1 % gophacide (1 day)	9	42	30	39	40	35	38	42	4	—	0	0	0	0	100·0
	10	0	4	6	4	0	2	4	6	—	0	0	0	0	100·0
	11	28	44	41	45	41	41	56	3	—	3	8	3	5	88·0
0·1 % gophacide (4 days)	12	7	8	8	10	5	5	9	6	0	0	0	0	0	100·0
	13	9	13	12	16	10	12	15	3	2	0	8	9	7	52·0
	14	8	15	12	13	15	16	21	6	4	3	10	16	22	0·0
0·25 % gophacide (1 day)	15	4	13	19	18	29	19	28	9	—	2	4	4	4	74·1
	16	7	10	10	10	10	14	16	5	—	2	4	2	2	73·0
	17	9	6	8	5	30	15	20	9	—	3	3	4	5	46·4
0·25 % gophacide (4 days)	18	9	17	13	10	10	12	10	1	7	8	12	10	8	22·4
	19	5	18	17	19	19	15	12	2	1	0	0	0	0	100·0
	20	92	163	189	210	101	131	150	16	4	5	15	17	14	91·9
3·0 % zinc phosphide (1 day)	21	18	20	24	23	10	12	18	6	—	22	21	38	28	0·0
	22	97	154	158	161	106	156	102	16	—	33	36	26	26	78·8
	23	18	20	20	20	20	22	23	7	—	0	0	0	0	100·0
3·0 % zinc phosphide (4 days)	24	8	10	14	14	12	6	14	8	1	11	14	12	16	0·0
	25	10	9	11	12	7	14	17	7	6	2	4	3	2	73·8
	26	15	30	32	17	28	58	44	4	2	0	4	8	8	78·7

Table 3. *The results of the analysis of co-variance on the maximum pre- and post-treatment census bait takes in Table 2*

Source of variation	Degrees of freedom	Mean square	Variance ratio (F)	Significance (P)
Residual error in post-treatment takes	12	114·0	—	—
Regression on initial size in error	1	218·6	1·9	Nil
Deviations from regression in error	11	1149·4	—	—
Length of poisoning (adjusted)	1	1·0	1·0	Nil
Poisons (adjusted)	2	335·3	1·6	Nil
Interaction: poisons × length of poisoning	2	284·7	1·4	Nil
Gophacide *v.* zinc phosphide (adjusted)	1	327·8	3·1	Nil
Between gophacide concentrations (adjusted)	1	6·8	1·0	Nil

'favourable' environments (i.e. where food sources were both scanty and separated from cover). Under these conditions mice were most readily intercepted and drawn to poison baits laid directly. In the small premises treated directly with gophacide bait alternative food supplies were limited and in the pre-treatment censusings the mice appeared to be quickly drawn to the census baits for there was no great increase in the numbers of wheat grains taken after day 1 (Table 1).

In the pre-baiting/poisoning trials (Table 2) various premises were used including kitchens, a restaurant, offices, shop-stores, a greengrocer's and an amusement hall. In contrast to the earlier treatments the mice living in them generally had ready access to food supplies and, not surprisingly in view of the competition provided by these other foods, the diversion of mice to the pre-treatment census bait was less rapid. For example, in the 12 premises treated with gophacide, the total consumption of canary seed during the pre-treatment census increased from 220 g. on day 1 to 341, 374 and 400 g. on days 2, 3 and 4 respectively, while during the pre-baiting period, 305, 320 and 383 g. of bait were eaten on days 1, 2 and 3 respectively.

In the direct gophacide treatments the greatest number of visits by mice to the poison baits was made on day 1 of the 4-day treatment period (Table 1). This was an expected result if, as believed, the mice were relatively hungry – although it is possible that the 3-day period between the end of the pre-treatment censusing and the beginning of the poison treatment was too short to prevent some degree of conditioned feeding. The numbers of baits disturbed on day 2 (53·2 % compared with day 1) indicates, however, that possibly some advantage was gained by continuing the direct poison treatments for a second day at least.

A similar result was obtained in the six 4-day gophacide treatments carried out after pre-baiting (Table 2). Thirty-four poison baits were visited on day 1 and 18 on days 2–4. Even so, an analysis of co-variance, using the data in Table 2 (but using maximum take on any one day of the 4 days of the pre- and post-censuses instead of the totals for the 4 days) and designed to allow for the effect of size of infestation, revealed no significant difference in effectiveness between the 1- and 4-day poison treatments or, furthermore, between the two concentrations of gophacide tested or between gophacide (total success 83·4 %) and zinc phosphide (total success 66·8 %) (Table 3). Most striking instead was the variable success achieved with each type of treatment. It can only be presumed that, unlike what happened in the direct poison treatments, some mice were not sufficiently attracted to the poison bait in spite of 3 days of pre-baiting. In five of the eight gophacide treatments that were not 100 % successful (nos. 11, 13, 14, 16 and 20) the amount of pre-bait eaten was still increasing when the poison was introduced. Thus it is possible that in these treatments better control would have resulted if pre-baiting had been continued for a longer period, or, alternatively, if a more attractive pre-bait had been used. In the other three treatments that failed there was no obvious trend in the amount of pre-bait eaten daily.

Judging from the results of the direct poison treatments gophacide, applied in bait directly, should effectively control mice that are short of other food. In most of the pre-baiting/poisoning trials, however, the amounts of pre-bait eaten increased daily suggesting that pre-baiting is advisable when gophacide is used against mice that are well supplied with other food. Support for this conclusion is found in the results of the two direct gophacide treatments on captive mice. Although the test animals were supplied with excess plain food, the latter was known to be less attractive to mice than either of the two baits in the direct treatments. Nevertheless, complete kills were not obtained even after treatment for 7–12 days.

The direct gophacide treatments were carried out by Ministry of Agriculture, Fisheries and Food staff from South-Eastern Region and the statistical analysis of the data was done by B. Rennison and G. Snell.

Gophacide was supplied by Bayer Agrochem Ltd.

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