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Field trials of brodifacoum (WBA 8119) against the house mouse (*Mus musculus* L.)*

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SUMMARY

The anticoagulant rodenticide brodifacoum was tested against house mice (*Mus musculus* L.) infesting farm buildings. In six trials, treatment success was assessed from the results of census baitings conducted before and after treatment. With 0·005 % brodifacoum in canary seed/corn oil bait, the control achieved ranged between 92·7 % and 100 %, mean 98·8 %. Two mouse populations were eradicated in 3 to 4 weeks but a few individuals survived each of the other four treatments which lasted 6 weeks. The effectiveness of brodifacoum against mice is compared with that of 0·1 % calciferol and 0·025 % warfarin in combination. It is concluded that brodifacoum and calciferol/warfarin are equally effective in controlling *M. musculus* but that brodifacoum treatments need to be conducted for a relatively longer period.

INTRODUCTION

Previous work on the potential of the new rodenticide brodifacoum [3-(3(4'-bromobiphenyl-4-yl)-1,2,3,4-tetrahydronaphth-1-yl)-4-hydroxycoumarin] against the house mouse, *Mus musculus* L., has been reported (Redfern, Gill & Hadler, 1976; Rowe & Bradfield, 1976). In laboratory feeding tests, brodifacoum was found to be highly toxic to *M. musculus*, including warfarin-resistant animals (Refern *et al.* 1976). Non-resistant mice died after feeding on 0·002 % brodifacoum bait for 2 days and although some resistant individuals survived the same feeding regime, all were killed when fed 0·005 % brodifacoum bait for 1 day. Brodifacoum, at concentrations in bait between 0·002 % and 0·01 %, also performed well in 21-day treatments against penned families of warfarin-resistant mice provided with alternative non-poisoned foods (Rowe & Bradfield, 1976). It was concluded from the results of the laboratory and pen studies that brodifacoum was more active against *M. musculus* than other known anticoagulant rodenticides and that bait containing between 0·002 % and 0·005 % brodifacoum would be most suitable for field use. The results of brodifacoum treatments that have since been carried out against free-living mice are reported below.

MATERIALS AND METHODS

For comparative efficacy purposes, the brodifacoum treatments carried out in pens were done using the same bait-base (pinhead oatmeal/5 % corn oil) employed in earlier work on other rodenticides (Rowe & Bradfield, 1975). However, previous studies on the food preferences of wild mice (Rowe, Bradfield & Redfern, 1974), showed that canary seed (*Phalaris canariensis*) was more acceptable than pinhead oatmeal; thus before the field trials were begun, laboratory tests were conducted to determine the efficacy of canary seed bait treated with brodifacoum. Poison bait was prepared by first dispersing the appropriate amount of brodifacoum in 5 % corn oil and then slowly adding the solution, with thorough stirring, to the canary seed. The constituted bait was allowed to stand for 3 days before use to enable the solution to penetrate beneath the seed husks. Feeding tests were then carried out using individually caged warfarin-resistant mice and bait treated with brodifacoum at either 0·002 %, 0·005 % or 0·01 %; complete kills of 4/4, 14/14 and 8/8 animals were obtained respectively (mean days to death 9·8, 8·6 and 6·8 days). Following the results of these tests, canary seed was chosen as the bait-base in the field trials.

Each of six field trials was conducted in the following manner. On day 1 the infested area was surveyed thoroughly and a pre-treatment census begun. For this purpose, pinhead oatmeal bait, of known weight, was laid in small covered plastic containers which were distributed a few feet apart throughout the infested area. Each bait point was inspected daily to ensure that surplus bait was always available and the total amount of census bait eaten was measured on each of 4 days. At the end of the pre-treatment census, the containers and surplus bait were removed and 3 days later the poison treatment was begun, using brodifacoum at 0·005 % in canary seed/5 % corn oil bait.

The poison bait points chosen were different from those employed in the census baiting. The poison bait was maintained in excess at each point throughout the treatment period and the total amount consumed each week was derived from the take of bait on each of the first 4 days and then over the last 3 days. The number of points at which mice fed was also recorded at each of the five weekly bait inspections. When the amount of poison bait eaten and visits to the bait points had fallen to a relatively low level, smoothed areas of an inert dust were strategically placed in the treated premises. The treatment was terminated either when the poison bait was no longer being eaten and the dust patches remained untouched or when, after 6 weeks, there was still a regular, albeit small, take of poison bait and activity in the dust patches. At the end of the treatment period the poison bait and containers were removed and, after an interval of 3 days, a post-treatment census, conducted in the same manner as the pre-treatment census, was begun. Percentage success in each treatment was estimated from the total amounts of pinhead oatmeal eaten during the pre- and post-treatment censuses.

Table 1. *The results of* 0·005 % *brodifacoum treatments against* M. musculus

Treatment no.	Consumption of pre-treatment census bait (g)	Consumption of poison bait		Number of takes of poison bait	Consumption of post-treatment census bait (g)	Estimated success (%)
		Week	Amount (g)			
1	115	1	182	79	0	100
		2	12	11		
		3	2	1		
2	347	1	319	117	4	98·8
		2	74	30		
		3	53	6		
		4	47	24		
		5	47	18		
		6	23	14		
3	58	1	370	69	0	100
		2	128	52		
		3	73	20		
		4	15	10		
		5	0	0		
4	79	1	152	63	3	96·2
		2	72	40		
		3	79	30		
		4	41	33		
		5	13	9		
		6	2	2		
5	124	1	371	58	9	92·7
		2	329	76		
		3	166	66		
		4	59	39		
		5	80	22		
		6	25	18		
6	803	1	1964	178	2	99·8
		2	863	163		
		3	445	111		
		4	280	94		
		5	211	88		
		6	95	53		

RESULTS AND DISCUSSION

The chosen premises had histories of persistent mouse infestation but no frequent or prolonged warfarin treatments had been carried out in them and the mice present were not suspected to be warfarin-resistant. This conclusion was supported by the results of laboratory feeding tests on small samples of mice which were taken from three of the premises before the trials were begun. None of the mice survived 21 days feeding on 0·025 % warfarin bait, the criterion adopted for resistance to warfarin in *M. musculus* (Rowe & Redfern, 1965); mortalities of 5/5, 4/4 and 5/5 were obtained in 7–14, 7–16 and 3–10 days respectively.

The amount of brodifacoum bait eaten by mice in each week of the six treatments is shown in Table 1 together with the corresponding number of bait points at

which feeding occurred. With the exception of treatment 5, there was a marked decline in poison bait consumption after week 1 and, thereafter, the bait take and the proportion of bait points visited by mice tended to continue to fall. In treatments 1 and 3, feeding on poison bait and activity in the dust patches ceased during weeks 3 and 4 respectively and the post-treatment census baitings confirmed that both had been completely successful. Although the remaining four treatments were continued for 6 weeks, there were signs that a few mice were still present at the end of each poisoning period. The estimated success obtained in the six treatments ranged between 92·7 % and 100 %, mean 98·8 %.

Different explanations can be put forward to account for the survivors of the prolonged brodifacoum treatments – the residual animals were physiologically resistant to brodifacoum, the poison bait had become less effective with age, immigrant mice had penetrated the treated premises or there had been inadequate feeding on the poison bait. There was no evidence of brodifacoum resistance in the laboratory findings (Redfern *et al.* 1976) and, although the two mice which survived the pen treatments also survived a further 21-day feeding period on 0·002 % and 0·005 % brodifacoum bait respectively, they died 12 and 16 days after the poison bait was withdrawn (Rowe & Bradfield, 1976). In the present work furthermore, the pre-treatment sampled mice were found to be susceptible to warfarin, which under laboratory conditions proved less active than brodifacoum against *M. musculus* (Redfern *et al.* 1976). Laboratory feeding tests conducted on mice surviving one of the four incompletely successful treatments showed that the survivors were susceptible to brodifacoum. The three surviving mice (two males, one female) of treatment 4 were live-trapped immediately after the post-treatment census had been completed. After a 7-day rest period in the laboratory, the individually caged animals were offered brodifacoum bait recovered from the treated premise; all three mice died within 7 days and, in each case, autopsy revealed typical symptoms of anticoagulant poisoning. Confirmation that the 6-week-old poison bait was toxic to *M. musculus* was derived from the same feeding tests.

Although the buildings selected for the trials were isolated their penetration by individual mice ranging outdoors cannot be completely excluded (Rowe & Swinney, 1977). The high mortality of resident mice during the early stages of each treatment and the long treatment periods were both factors favouring successful immigration during the trials. Even so, the most likely explanation to account for the difference in effectiveness of the brodifacoum treatments and the presence of some survivors involves the known feeding traits of *M. musculus*. The early work of Southern (1954), showed that there is considerable individual variation in feeding behaviour and that particular difficulties were encountered in drawing entire mouse populations to feed on poison bait when alternative foods and cover are abundant. In the present trials, the latter conditions prevailed in those buildings where incomplete control was gained. In contrast, the existing food supplies in the building used for treatment 1 were relatively scanty and also irregularly distributed; there, the mouse population was rapidly diverted to the poison bait (Table 1) and complete control was obtained within 3 weeks.

Brodifacoum performed better than various acute poisons that have been recently evaluated against mice under comparable field conditions (Rowe, Swinney & Bradfield 1974; 1975). The control achieved in the brodifacoum treatments was similar to that obtained using bait containing 0·1 % calciferol and 0·025 % warfarin (Rowe, Smith & Swinney, 1974). This poison combination, like brodifacoum, is effective against warfarin and other anticoagulant-resistant mice (Rowe & Bradfield, 1975). In six field trials employing calciferol/warfarin in canary seed bait, the control obtained ranged between 97·0 % and 100 %, mean 98·6 %. However, with one exception, feeding on calciferol/warfarin bait ceased early in week 2 and the treatments were then terminated. Thus, in further comparison with calciferol/warfarin, it is concluded that treatments employing brodifacoum against mice need to be conducted for a relatively longer period to gain the same measure of control.

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