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Field trials of flocoumafen* against warfarin-resistant infestations of the Norway rat (*Rattus norvegicus* Berk.)

By A. P. BUCKLE

Mammals and Birds Department, Tolworth Laboratory, Agricultural Science Service, Ministry of Agriculture, Fisheries and Food, Hook Rise South, Tolworth, Surbiton, Surrey KT6 7NF

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SUMMARY

The anticoagulant rodenticide flocoumafen was tested against warfarin-resistant Norway rats (*Rattus norvegicus* Berk.) infesting farm buildings. Complete control was obtained in 10–21 days (mean 14·2 days) in six treatments in which baits poisoned with 0·005% flocoumafen were maintained, in surplus, until rats ceased to feed from them. A further six treatments, in which the application of poisoned bait was restricted to periodic placements of 50 g, were also completely successful in 15–30 days (mean 21·0 days). Less poisoned bait was used in the restricted flocoumafen treatments than in the unrestricted treatments but the time taken to control the rat infestations was significantly longer.

INTRODUCTION

Laboratory studies of the new anticoagulant rodenticide flocoumafen [4-hydroxy-3(1,2,3,4-tetrahydro-3-(4-(4-trifluoromethylbenzyloxy) phenyl)-1-naphthyl) coumarin] showed the compound to be highly active against warfarin-resistant and susceptible *Rattus norvegicus* (Bowler, Entwistle & Porter, 1984). This paper describes field trials of flocoumafen conducted on farms in the Anglo-Welsh border country where the incidence of resistance to warfarin among *R. norvegicus* populations is commonly about 50%. Some experimental treatments were carried out using an unrestricted baiting scheme (Richards, 1981), and others were conducted in which the application of poison was restricted to the periodic placement of limited quantities of bait. The latter system, proposed for the practical and safe use of flocoumafen (Bowler, Entwistle & Porter, 1984), has been termed pulsed baiting (Dubock, 1979, 1984) and minimal baiting (Richards & Huson, 1985).

METHODS

General

According to the manufacturer's recommendation, the flocoumafen bait was made up from laboratory-prepared master-mixes to a final concentration of 0·005%

* Proposed common name.

of the active ingredient. Stabilized medium oatmeal was used as the bait base at the beginning of each treatment but, occasionally, it was necessary to change to soaked wheat when it became apparent that the dry bait was proving insufficiently attractive.

The 12 farms used in the study were selected so that they were similar to those employed in previous investigations (see, for example, Rennison & Dubock, 1978; Richards, 1981) and were neither too lightly nor too heavily infested (Rennison, 1974). Before each trial began, the farm was surveyed by an experienced operator to determine the extent and intensity of the rat infestation and clean wooden bait trays were put down where rat activity was apparent (Tables 1 and 2). When necessary, particularly when baits were placed out-of-doors, available materials, such as corrugated iron, wooden boards, empty fertilizer bags and drainage pipes, were used to protect the bait from the weather and from non-target animals.

Unrestricted baiting

In the six unrestricted treatments, poisoned baits weighing about 100 g were laid on Monday on trays that had been placed the previous Thursday or Friday (Richards, 1981). Sites were visited daily (Monday–Friday) to count the number of trays visited by rats, to weigh the uneaten bait and to replenish the trays with the aim of maintaining a surplus of bait throughout the treatments (see Drummond & Rennison, 1973). Baiting continued until takes of bait had ceased and there were no other signs of rat activity. To assist this judgement, a number of patches of fine sand were sited on each farm, independent of the bait points, checked daily for rat signs and smoothed over.

Restricted baiting

In the six restricted treatments, poisoned baits weighing 50 g were laid, as in the unrestricted treatments which preceded them, on Monday. The sites were visited daily to weigh the uneaten bait but, in these trials, the bait placements were topped-up, where necessary, to 50 g only on Mondays and Fridays, until there were no more complete takes of bait and, thereafter, only on Mondays. Baiting continued until bait takes ceased and, once again, rat activity at sand patches was used as supplementary information.

RESULTS

Unrestricted baiting

The numbers of bait trays visited daily by rats in the unrestricted treatments were summed and plotted on the monitoring graph (Drummond & Rennison, 1973) as proportions of the number of takes recorded on day 2 (Fig. 1). A relative assessment of the quantities of bait eaten by rats on each farm was obtained as the quotient of the weight of bait eaten during the trial and the maximum daily number of bait points at which bait takes were recorded (Table 1). This value ranged, in the unrestricted treatments, from 0·10 to 0·47 kg (mean 0·26 kg) per point, and the treatments were successfully completed in 10–21 days (mean 14·2 days).

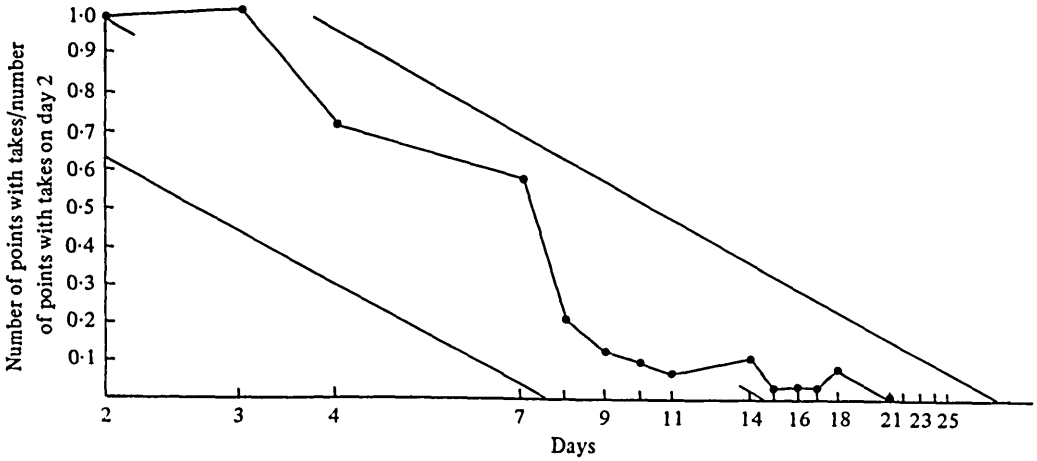

Fig. 1. Results, from the second day, of unrestricted poison-baiting trials with 0·005% flocoumafen; the oblique lines are the 95% confidence limits between which the plotted proportions should fall when a warfarin-susceptible rat population is treated with 0·025% warfarin (mean of six treatments).

Table 1. *The results of the unrestricted poison-baiting treatments with 0·005% flocoumafen against warfarin-resistant rats*

Farm	No. of bait points laid	Maximum daily no. of bait points with take	Weight of poisoned bait consumed by rats (kg)	Weight of bait consumed per bait point with take (kg)	Time to complete control (days)
1	58	35	6·75	0·19	14
2	38	26	12·31	0·47	16
3	22	14	2·99	0·21	10
4	25	21	3·70	0·18	9
5	41	30	2·95	0·10	21
6	59	33	12·43	0·38	15

Table 2. *The results of the restricted poison-baiting treatments with 0·005% flocoumafen against warfarin-resistant rats*

Farm	No. of bait points laid	Maximum daily no. of bait points with take	Weight of poisoned bait consumed by rats (kg)	Weight of bait consumed per bait point with take (kg)	Time to complete control (days)
1	43	29	3·41	0·12	15
2	22	16	1·51	0·10	30
3	86	38	6·11	0·16	22
4	47	35	4·64	0·13	22
5	53	42	4·34	0·10	21
6	49	33	3·85	0·12	16

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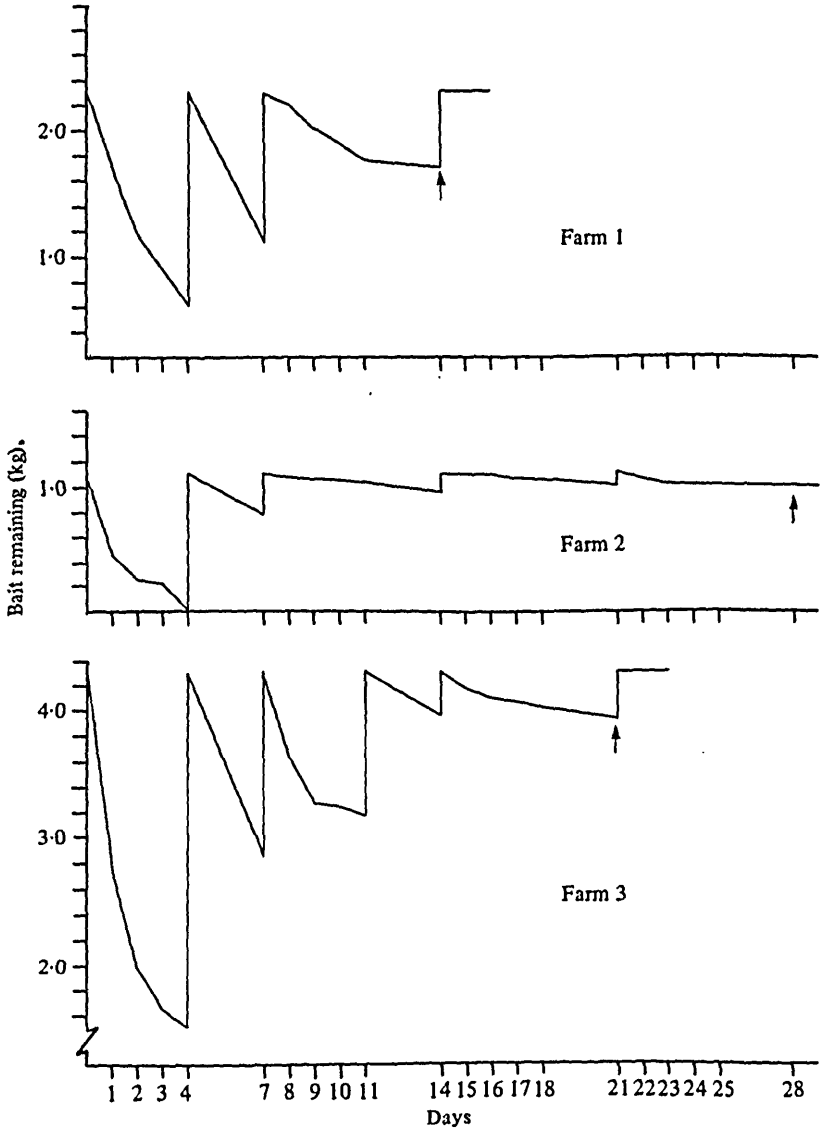

Fig. 2. For legend see opposite.

Restricted baiting

The infestations used in the restricted baiting treatments were similar to those used in the unrestricted treatments (Tables 1 and 2); there being no significant difference either in the numbers of bait points required to bait them ($t = 0{\cdot}89$, $P > 0{\cdot}1$) or in the maximum daily number of the points laid from which rats consumed bait ($t = 1{\cdot}15$, $P > 0{\cdot}1$).

On all of the farms receiving the restricted baiting treatment (except farm 3), bait takes were sufficient on days 1–4 to result in there being little or no bait available to the rats during the latter part of the first week of baiting (Fig. 2). As the treatments progressed, however, and baits were replenished according to

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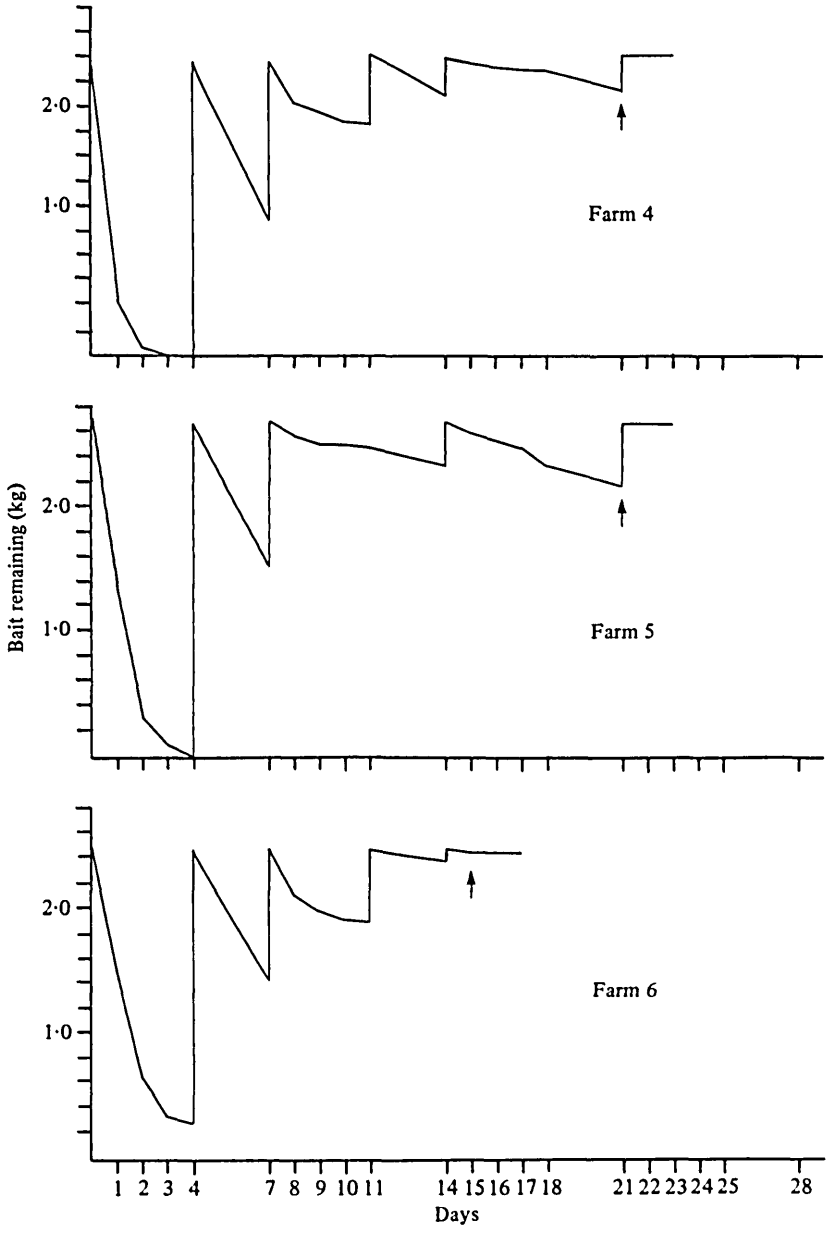

Fig. 2. Results of restricted poison-baiting trials with 0·005% flocoumafen expressed as the total weight of bait remaining uneaten by rats at each visit. The arrows indicate the last days on which rat activity was recorded at the bait points. Activity ceased simultaneously at bait points and tracking patches except on farm 2, where rat activity was recorded last at a single tracking patch on day 29 of the treatment.

schedule, less bait was eaten between visits until, in 15–30 days (mean 21·0 days), bait takes ceased (Table 2). Only in the later stages of the treatments of farms 2 and 3 was it necessary to change the bait base used from medium oatmeal to soaked wheat. The weight of bait eaten per point by rats ranged from 0·10 to 0·16 kg (mean 0·12 kg).

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DISCUSSION

Unrestricted poison baiting with 0·005% flocoumafen resulted in the complete control of *R. norvegicus* infestations containing warfarin-resistant individuals in about the same time as similar treatments with 0·005% difenacoum (Rennison & Hadler, 1975), 0·002% brodifacoum (Rennison & Dubock, 1978) and 0·005% bromadiolone (Richards, 1981), and treatments of warfarin-susceptible populations with 0·025% warfarin (Drummond & Rennison, 1973).

The infestations used in the unrestricted and restricted flocoumafen treatments were similar, both in terms of the numbers of bait points required to bait them and the maximum daily numbers of bait points at which takes were recorded, but there were two important differences in the results of the treatments. Firstly, while it took on average only 14·2 days to complete the unrestricted treatments, the restricted treatments required significantly ($t = 2{\cdot}42$, $P < 0{\cdot}05$) longer (on average 21·0 days) to achieve a similar result, and secondly, although the restricted treatments were of longer duration, significantly ($t = 2{\cdot}31$, $P < 0{\cdot}05$) less bait was consumed by rats while they were in progress (Tables 1 and 2).

The advantages of pulsed or minimal baiting over surplus baiting with second-generation anticoagulants were recently given as lower labour and bait requirements and reduced non-target hazard (Bowler, Entwistle & Porter, 1984). Although, because of the schedule of visits imposed by the monitoring programme, it is difficult to compare directly the labour requirements of the unrestricted and restricted treatments described here, it is clear that the potential advantage of fewer visits with restricted baiting was offset, at least in part, by the longer duration of the treatments.

Primary hazard to non-target animals, stemming from the conventional use of rodenticides on farms, is kept to a low level by the careful placement and secure covering of bait points. In the restricted treatments, what primary hazard existed was further reduced by the smaller bait placement size and, particularly during the first week, by the fact that substantial quantities of bait were eaten by rats and not immediately replaced and, therefore, little or no bait was available for consumption by other animals. However, this latter advantage was not apparent during the final stages of the restricted treatments and, once more, must be balanced against their longer duration. Clearly, a restricted system whereby bait placements are reduced in size at successive visits would limit the quantity of bait available to non-target animals towards the end of treatments, but it remains to be shown that such a practice is compatible with efficient rodent control on farms.

Rats consumed less poisoned bait during the restricted treatments than during the unrestricted treatments and, presumably, their bodies therefore contained smaller residues of the anticoagulant (see Dubock, 1984). Whether this results in a real reduction in secondary hazard can be determined only when more is known about residue levels in rat bodies and about the susceptibility of non-target species to secondary poisoning but, arguably, any reduction in the quantity of rodenticide used must be considered advantageous.

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