J. Hyg., Camb. (1961), **59**, 413
Printed in Great Britain

Sodium fluoracetate and fluoracetamide as 'direct' poisons for the control of rats in sewers

By E. W. BENTLEY, L. E. HAMMOND, A. H. BATHARD and J. H. GREAVES

Infestation Control Laboratory, Ministry of Agriculture, Fisheries and Food, Tolworth, Surbiton, Surrey

(*Received* 26 *April* 1961)

INTRODUCTION

Field trials carried out during the last war by the Ministry of Food and the Bureau of Animal Population, Oxford, showed that poisons such as 5% zinc phosphide are more effective against rats in sewers when used with pre-baiting than when used without it (Chitty & Southern, 1954). The same will undoubtedly be true of poisons such as antu (alpha-naphthylthiourea), sodium fluoracetate and fluoracetamide when used at dosage levels and in situations where a 100% kill cannot be achieved with either method.

However, there is reason to think that both sodium fluoracetate and fluoracetamide, if not antu, are very much more palatable to rats than zinc phosphide; and that, when they are used as direct poisons—even at a comparably somewhat higher concentration in bait than usual—they give rise to appreciably less sub-lethal dosing and consequent bait and poison shyness. In the case of sodium fluoracetate this belief, and the fact that direct poisoning only involves one lifting of the sewer manhole covers while pre-baiting involves at least three (and therefore that more frequent direct poisonings than pre-baiting operations are possible per year for the same expenditure of manpower), have prompted its use experimentally on a number of occasions. Two such occasions have been described by Barnett & Bathard (1953). These authors used the poison at 1%. In one sewer system a kill of 91% was estimated to have been obtained in a single treatment, while in a second area a simultaneous direct poison operation with $2\frac{1}{2}$% zinc phosphide gave only a 35% kill. Six months later, when the populations were believed to have recovered fairly completely, a direct poisoning with 1% sodium fluoracetate in the second area gave an estimated kill of 90%, while 5% zinc phosphide, used now in the first system, gave an apparent kill of only 52%.

This report describes the results of several more trials with sodium fluoracetate and also with the somewhat similarly acting fluoracetamide, the rodenticidal properties of which, vis à vis sewer rat control, have been discussed by Bentley & Greaves (1960).

METHODS

The basic procedure in every trial was to choose a fairly self-contained, infested sewer system or subsystem of 100–200 manholes, and carry out a comparative 'census' of the rat population before and after poisoning. This involved the measurement, each day for 7–10 days, of the quantity of bait eaten during the previous 24 hr. at a number (30–50) of 'census manholes', in which a surplus of wheat had been maintained. The census manholes were distributed fairly evenly throughout the system to be treated but otherwise were deliberately located at street junctions and similar points where rat-traffic could be expected to have been higher than if they had been sited at random. This procedure probably led, on the average, to a slight underestimate of the percentage kill when the latter was less than 100 %.

In the poisoning operations 2 oz. baits were laid in the usual way, either on the benchings at the base of each manhole or on a galvanized tray fixed to the wall of the shaft and provided with a thick rope to encourage rats to climb up. As far as possible, and especially in the 'paired' treatments presently to be described, a visual estimate was made of the bait-take on one or more days following the poison baiting—but the bait was not augmented or disturbed in any other way.

More details of the circumstances of individual trials will be given below.

RESULTS

The results of twenty-two field trials in sewers are summarized in Table 1. Trials A–H formed part of a study of the recovery rates of rat populations after reduction by poisoning and are the control treatments carried out in Systems A–H of Bentley, Bathard & Riley (1959). In Trials A–E the poison was 0·25 % sodium fluoracetate in damp sausage rusk and, except in 'A', the bait contained a preservative against moulds. Only one treatment was done in each system, the apparent percentage kill ranging from 86 to 100 %. Further comments on the validity of these percentages will be found in Bentley *et al.* (1959).

Trials F–H provided an opportunity for a rough check on the relative efficiency of sodium fluoracetate and fluoracetamide and also of antu, which, because of its high toxicity to *Rattus norvegicus*, has also been suggested as a direct poison for controlling rats in sewers. Each trial consisted of four treatments, spaced out at 3-monthly intervals. Sodium fluoracetate at 0·25 % was used in 'F', antu at 2 % in 'G' and fluoracetamide at 1 % in 'H'. The bait-base was again damp sausage rusk, with paranitrophenol as a preservative.

Table 1 shows that in 'H' fluoracetamide gave good results (an estimated kill of 97·6 %) but that in both 'F' and 'G' the reduction in population size achieved was disappointing (46 and 32 % kills, respectively). In both areas therefore it was decided to do two further treatments with 1 % fluoracetamide with a 3-monthly interval between them. The precise effects of these treatments, by themselves, cannot be assessed from Table 1, since the pre-census figures quoted are merely a repetition of the post-census results of the previous operations and a recovery period of 11–12 weeks was allowed to precede the changeover to fluoracetamide. It is valid however, to conclude (see the figures in parentheses in Table 1) that in

'F', the combined effect of four treatments with 0·25 % sodium fluoracetate and two with 1 % fluoracetamide was to reduce the population by 79 %; and that in 'G', four treatments with 2 % antu and two with 1 % fluoracetamide eliminated about 78 % of the rats.

Table 1. *Summary of results of poisoning trials against sewer rats*

Area	Poison*	Conc. (%)	No. of treatments	Preservative*	Pre-census† take (g.)	Post-census take (g.)	Success†
A	NaFAc	0·25	1	—	445	0	100·0
B	NaFAc	0·25	1	0·15 % DAA	1633	225	86·2
C	NaFAc	0·25	1	0·25 % PNP	2848	143	95·0
D	NaFAc	0·25	1	0·15 % DAA	1758	102	94·2
E	NaFAc	0·25	1	0·15 % NaDAA	3331	240	92·8
F	NaFAc	0·25	4	0·25 % PNP	3145	1708	45·7
F	F/amide	1·0	2	0·25 % PNP	1708 (3145)	672	60·7 (78·6)
G	Antu	2·0	4	0·25 % PNP	3578	2437	31·9
G	F/amide	1·0	2	0·25 % PNP	2437 (3578)	770	68·4 (78·5)
H	F/amide	1·0	4	0·25 % PNP	2069	50	97·6
J	F/amide	2·0	2	—	393	0	100·0
K	NaFAc	0·25	2	—	3255	132	95·9
L1	F/amide	2·0	2	—	262	0	100·0
L2	NaFAc	0·25	2	—	1767	30	98·3
M1	F/amide	2·0	2	—	233	0	100·0
M2	NaFAc	0·25	2	—	707	33	95·3
N1	F/amide	2·0	2	—	2422	0	100·0
N2	NaFAc	0·25	2	—	860	0	100·0
O1	F/amide	2·0	2	—	1478	0	100·0
O2	NaFAc	0·25	2	—	3282	50	98·5
P1	F/amide	2·0	2	—	4395	5	99·9
P2	NaFAc	0·25	2	—	4900	132	97·3

* The abbreviations used are as follows: NaFAc, sodium fluoracetate; F/amide, fluoracetamide; DAA, dehydroacetic acid; NaDAA, the sodium salt of dehydroacetic acid; PNP, paranitrophenol.

† See text for explanation of the figures in parentheses.

At this stage fluoracetamide appeared to be sufficiently effective as a direct poison in sewers to justify comparison with sodium fluoracetate in a series of paired trials: and for reasons given by Bentley & Greaves (1960), it was thought that the concentration of fluoracetamide should be increased to 2 %. It was decided to omit the fungicide since this might cause some lowering of acceptance of the bait, and because previous observations had shown that in sodium fluoracetate treatments very little feeding seems to occur after the first 48 hr.

The results of six pairs of trials (Trials J–P) are shown in Table 1. In five of these it was possible to use sodium fluoracetate and fluoracetamide in different parts of the same sewer system. Each trial consisted of two treatments only, spaced 3 months apart. In every case, in the first treatment, the bait-base was damp sausage rusk. In the second, it was damp pinhead oatmeal.

DISCUSSION

Paradoxically, because zinc phosphide, arsenious oxide and antu, following a period of pre-baiting, have been used for many years for the control of rats in sewers, very little information of statistical value is available to show how effective these poisons are. However, the small number of exact measurements that have been made, combined with a great volume of circumstantial evidence from the records of local authorities, suggest that kills of 90% or more are exceptional. The results of Trials A–E, where only a single treatment was done, therefore suggest that direct poisoning with sodium fluoracetate at 0·25% is at least as effective as pre-baiting/poisoning with the 'standard' poisons.

It is less easy to compare the effects of two or more direct poisoning treatments using sodium fluoracetate or fluoracetamide and spaced at 3-monthly intervals, with one or more pre-baiting/poisoning trials carried out every 6 months with, say, zinc phosphide. Two points may be made however. First, that the results of the paired trials ('J' onwards in Table 1), consisting each of only two treatments, were almost as good as could have been wished: and secondly, they were mostly carried out in areas where zinc phosphide and arsenic had been used previously without reducing the population beyond a certain, not insignificant, level. That the comparison is not invalidated because the post-censuses of Table 1 followed the last treatment of each trial—whereas local authorities usually have to base their estimate of the success of a given treatment on the size of the population at the next, 6 months later—is indicated by the fact that in six areas (A, J, M1, M2, N1, N2), where a 100% kill was achieved, the local authorities concerned reported freedom or almost complete freedom from rats several months later. On the other hand, it must be recorded that our treatments were probably carried out in a more conscientious and efficient manner than can be expected from local authority operators. On balance, there is little doubt in our minds that better results will usually be obtained by direct poisoning with sodium fluoracetate or fluoracetamide at 3-monthly intervals than by 6-monthly pre-baiting/poisoning with zinc phosphide or arsenious oxide. It is debatable whether or not 6-monthly treatments with sodium fluoracetate or fluoracetamide *with pre-baiting* would give even better results. This is unlikely to be the case, at least, in sewers in which immigration of rats from elsewhere accounts for a substantial part of the build-up of populations between treatments. Here, frequent 'good' treatments may result in a lower average level of population of rats than less frequent treatments that produce a complete kill.

In comparing the efficiency of sodium fluoracetate with that of fluoracetamide it is reasonable to take into account only the trials in which the latter poison was used at 2%. When this is done it is obvious that fluoracetamide performed significantly better than 0·25% sodium fluoracetate—whether the comparison is between the trials that were done in pairs or whether all twelve of the sodium fluoracetate trials of Table 1 are taken into consideration. And as fluoracetamide has slight advantages in other directions (Bentley & Greaves, 1960), on present information its use in preference to sodium fluoracetate for the control of rats in sewers, would seem to be indicated.

In considering whether to incorporate an 'anti-mould' in baits containing sodium fluoracetate or fluoracetamide it is not possible to compare the results of the trials in which anti-moulds were used and those in which they were not. This is because, in the latter case, more treatments were carried out per trial. However, the results of the trials in which the fungicides were omitted were so good that there is clearly no case at present for incorporating these additives in the baits.

SUMMARY

1. Field trials suggest that 3-monthly operations against rats in sewers using either 0·25 % sodium fluoracetate or 2 % fluoracetamide as a direct poison are more effective than 6-monthly treatments with 2·5 % zinc phosphide or 10 % arsenious oxide using the pre-baiting method.

2. In six paired trials 2 % fluoracetamide gave better results (an apparent 100 % clearance in five instances) than 0·25 % sodium fluoracetate.

3. There is no evidence, at present, that direct poisoning treatments with 2 % fluoracetamide or 0·25 % sodium fluoracetate are improved by the addition of mould inhibiting substances to the bait.

The work described above was made possible only by the co-operation of a large number of local authority councils and their staffs, to whom we are therefore much indebted. We wish to thank also, Mr J. D. Riley who gave considerable help during the early stages of the trials.

REFERENCES

Barnett, S. A. & Bathard, A. H. (1953). Population dynamics of sewer rats. *J. Hyg., Camb.*, **51**, 483.

Bentley, E. W., Bathard, A. H. & Riley, J. D. (1959). The rates of recovery of sewer rat populations after poisoning. *J. Hyg., Camb.*, **57**, 291–8.

Bentley, E. W. & Greaves, J. H. (1960). Some properties of fluoracetamide as a rodenticide. *J. Hyg., Camb.*, **58**, 125.

Chitty, D. & Southern, H. N. (1954). *Control of Rats and Mice.* Oxford: Clarendon Press.