SODIUM FLUORACETATE (1080) AS A RAT POISON

By S. A. BARNETT and MARY M. SPENCER
Ministry of Agriculture and Fisheries, Infestation Control Division, London

INTRODUCTION

Finding poisons for rat control presents two major difficulties. First, poisons highly toxic to rats are usually dangerous to men and domestic animals. Second, it is well established that the behaviour of rats towards unfamiliar food is, though not 'intelligent', of a kind likely to make consistently good kills by simple poison baiting difficult (Chitty & Shorten, 1946; Thompson, 1948; Shorten, 1950).

Among the most toxic rat poisons high claims have been made for sodium monofluoracetate, or 1080, (Kalmbach, 1945, 1947; Chenoweth & Gilman, 1946; Ward, 1946). It has been claimed that this poison can be used with success against rats (*Rattus norvegicus* Berkenhout and *R. rattus* L.) without the preliminary prebaiting with plain bait recently recommended as essential for successful poison baiting (Middleton, 1945; Barnett, 1946, 1948). The main purpose of this study is to give evidence on this question.

TESTS OF DIRECT POISONING AND PREBAITING

Methods. The method of testing the effectiveness of a poison baiting was that of Chitty & Shorten (1946). A surplus of whole wheat is laid at many points throughout the infested area, and the wheat eaten in 24 hr. is recorded until the daily take has been steady for 3 days. The wheat must be laid in places where it will not be eaten by other animals; in the open it was usually laid in 15 in. lengths of 3 in. drain piping blocked at one end. These pipes may be entered by mice, but mice did not interfere materially at any of the sites used. The poison bait was laid 3 days after the end of the census, at numerous points throughout the area, in amounts of 30 g. In rural habitats it was usually put in holes, and stringent precautions were taken to leave it where it would be accessible only to rats. All residues were cleared up on the day after poison was laid. A second census was begun on the day after poison baiting, and the figures of take for the third, fourth and fifth day of the census were taken to represent the new population level. When a third census was required, it was done in the same way as the second.

When poisoning was preceded by prebaiting, prebaiting began the day after the end of the census and was continued for 4 days; poison was then laid on the fifth day and cleared up on the sixth. However, when all the prebaiting and poisoning was done in holes out of doors, prebaiting was carried out only on the first and third days, and poisoning on the fifth. Prebaiting procedures were the standard ones recommended in the handbook published by the Ministry of Food (Barnett, 1946) which should be consulted for details of baiting methods.

Results. The results of direct poisoning with sodium fluoroacetate are given in Table 1. Thirteen tests were done on *R. norvegicus*. In eight of these, censuses showed kills of 89 % or more, and they can be considered successes. Of the remaining five, three were unqualified failures, but there is some doubt about the remaining two. In test no. 118 there was a good deal of disturbance during the experiment, which may have prevented a higher kill. As for test no. 121, it was learnt that a few weeks before the test an attempt had been made to kill the rats by ordinary methods, and that the bait base used had been damp sausage rusk, which was also used with sodium fluoroacetate in the experiment. It is therefore possible that the rat population was already bait-shy to the bait base (Rzoska, 1950). Ignoring, therefore, the two doubtful cases, we had three failures in eleven tests.

Three tests were done against *R. rattus*. One was a failure, and two were successes.

Given these results, an obvious question is: is it possible to improve on this record by prebaiting? Table 2 records six tests (one against *R. rattus*) in which 1080 was used after prebaiting. Five were unequivocal successes; one, no. 110, gave an estimated kill of 81–83 %.

TESTS OF SHYNESS

Methods. 'Shyness' is the refusal of food which has previously caused illness; it may be displayed to poisons, or to a bait base which has been eaten with a poison (Rzoska, 1950). Shyness due to ingestion of baits containing 1080 was tested for as follows.

In some of the field experiments there were large residual populations which had had access to baits

Table 1. *Tests of direct poisoning and shyness*

Test no.	Habitat	Direct poisoning: bait base	1080 (%)	Census 1 average g.	Census 2 average g.	Estimated success (%)	Second poisoning: bait base	Census 3 average g.	Estimated success (%)
155	Hedges behind slaughterhouse	Rusk	1	1333	687	44·6–56·6	Barley	493	17–33·4
157	Pet store	Rusk	1	1267	893	21·1–37·6	Barley	737	11·6–26·4
453	Refuse tip	Barley	1	8068	5400	16·3–40·5	Rusk	623	82·3–90·8
119	Refuse tip	Rusk	1	7223	760	88·4–90	Barley	563	4–33
121	Refuse tip	Rusk	1	2696	1436	41·4–51·5	Barley	873	13·7–44·8
115	Sewage farm	Barley	1	1080	5	99·1–99·6	—	—	—
116	Hunt kennels	Barley	1	1120	62	93·4–94·6	—	—	—
117	Chicken run	Rusk	0·25	410	27	92·7–94·9	—	—	—
118	Salvage destructor works	Rusk	0·25	473	142	51·4–74·7	—	—	—
360	Refuse tip	Wheat	1	10233	30	99·6–99·7	—	—	—
361	Farm buildings	Wheat	1	3350	63	97·6–98·2	—	—	—
362	Farm buildings	Wheat	1	4280	37	98·1–99·2	—	—	—
363	Farm buildings	Wheat	1	2210	80	95–97·6	—	—	—
159*	Cabinet maker's	Rusk	1	262	212	0–33·8	Barley	178	0–32·9
455†	Herb factory	Rusk	1	250	20	88–93	—	—	—
456*	Restaurant	Rusk	1	1493	79	94–95	—	—	—

Table 2. *Prebaiting tests*

Test no.	Habitat	Bait base	1080 (%)	Census 1 average g.	Census 2 average g.	Estimated success (%)
112	Farm buildings	Barley	0·17	66	0	100
113	Farm buildings	Barley	0·17	162	0	100
161	Cafe	Barley	1·0	218	0	100
114	Hedges and waste ground	Barley	0·5	1601	28	96·9–98·4
108*	Skin-drying factory	Rusk	1·0	943	23	96·3–97·6
110	Licorice factory	Barley	1·0	740	132	81·1–82·7

Notes for Tables 1 and 2

Bait bases:

Rusk: a biscuit meal mixed with an equal weight of water.

Wheat: whole wheat soaked for 24 hours in water; surplus water drained off before use.

Barley: crushed barley kernels mixed with water in the ratio of either 1:2 or 1:2½ parts by weight.

Censuses:

The census figures are the average daily takes in g. for the last three days of each census.

Estimated success:

The figures given under this heading are the lowest and highest estimates of success, calculated from the peak and average takes during the relevant censuses (Chitty, 1950):

$$\text{Lowest estimate: } 100 - \frac{100 \times \text{peak census 2}}{\text{average census 1}}.$$

$$\text{Highest estimate: } 100 - \frac{100 \times \text{average census 2}}{\text{Peak census 1}}.$$

* *R. rattus* infestations.

† Mixed infestation of *R. norvegicus* and *R. rattus*.

containing 1080. These populations might therefore be either poison-shy to 1080, or bait-shy to the base used with the poison. The former possibility was tested by carrying out a pre-baiting treatment with a different bait base, followed on the fifth day by poisoning with 1080 in the second base. In an ordinary population this would be expected to give good results, as it did in the experiments recorded in Table 2. If, however, the population were poison-shy, this would be reflected in a relatively low percentage kill.

Results. The field tests gave evidence of shyness to 1080 in a new bait base in five out of six tests, of which one was against *R. rattus* (right-hand side of Table 1). In one test, no. 453, a gross failure of direct poisoning was followed by a successful prebaiting treatment. This was the exact opposite of the result of test no. 119, which was done in a similar habitat.

TOXICITY TESTS

Laboratory tests of toxicity were done on white *R. norvegicus* and wild *R. rattus*. The 1080* was administered orally in water solution.

The results of a test on male white rats weighing 120–420 g. were as follows:

Dosage (mg./kg.)	2·40	2·60	2·90	3·20	3·50
No. dosed	10	10	10	10	10
No. killed	1	0	2	3	2

Dosage (mg./kg.)	3·70	4·00	4·25	4·50	5·00
No. dosed	10	10	10	10	10
No. killed	3	4	10	10	10

The LD 50 was calculated by the method of Bliss (1935) with the aid of the tables of Fisher & Yates (1943):

LD 50 = 3·82; approx. range ($P = 0{\cdot}05$): 2·83–5·16.

The tests on *R. rattus* were on wild rats which had been trapped and kept in the laboratory for a few weeks or months; their weights were 100–275 g. The results were:

	Dosage (mg./kg.)	1·0	1·5	2·0	3·0	4·0
Males:	No. dosed	5	10	5	10	5
	No. killed	0	5	3	10	5
Females:	No. dosed	—	10	10	10	—
	No. killed	—	6	10	9	—

The numbers of rats were too small for calculation of LD 50, but show that the toxicity to *R. rattus* is of a similar order to the toxicity to the strain of white rats used. Dieke & Richter (1946), however, report a much higher toxicity to wild *R. norvegicus*.

DEATHS OF OTHER SPECIES

In spite of the care taken in laying and picking up the poison bait, one calf, three dogs, four cats, six chickens and twenty-five wild birds belonging to nine species (Table 3) were killed in nine out of the sixteen tests. The wild and domestic birds, the calf and one dog died through eating poison bait. The remaining dogs and all the cats were almost certainly poisoned as a result of eating dead or dying rats.

However carefully the poison is laid, there must always be some danger to wild birds; but the killing of domestic animals is a different matter. All occupiers of property on which tests were made were notified of the exact time of poison baiting, and of the dangers to their own animals, so that the deaths of dogs and cats through eating poisoned rats may be

* Supplied by Monsanto Chemicals Ltd.

Table 3. *Wild birds killed accidentally*

Name	No.
Chloris chloris chloris (greenfinch)	1
Corvus frugilegus frugilegus (rook)	2
Corvus monedula spermologus (jackdaw)	6
Erithacus rubecula melophilus (robin)	1
Fringilla coelebs coelebs (chaffinch)	11
Pica pica pica (magpie)	1
Prunella modularis occidentalis (hedge sparrow)	1
Troglodytes troglodytes troglodytes (wren)	1
Turdus merula merula (blackbird)	1

attributed to the negligence or indifference of their owners.

The circumstances in which animals died as a result of eating the poison bait itself are of greater interest. The dog which died in this manner escaped from the control of its owner and put its nose down a hole in which bait had been laid a few minutes before. It was dead within 2 hr. In the tests in which the calf and chickens were killed the 1080 was used with soaked wheat and was laid in rat holes. Afterwards, as much as possible was collected and the holes earthed up. At some points surviving rats re-opened the holes, and threw out grains of poisoned wheat. These grains were eaten by the chickens, and also, apparently, by the calf. Such accidents emphasize the dangers of using so toxic a poison as 1080 on farms and in other places where animals are kept.

DISCUSSION

The series of tests reported here is too small for a final assessment of 1080 as a rat poison. It has been claimed that 1080 is superior to zinc phosphide in making it possible to dispense with prebaiting (Kalmbach, 1947). The tests described here, in which an objective census technique has been used, show that the proportion of successes achieved with direct poisoning is higher with 1080 than with other poisons (Chitty, 1950; see also Barnett, 1948); an appreciable proportion of failures must, however, be expected. Another form of direct poisoning, in which 1080 is used in water solution, has been used with reported success in the United States (Kalmbach 1945; Simmons & Nicholson, 1947). No tests of this method have been made; it clearly has only a limited application, but possibly may be of value in special cases.

In view of the proportion of failures to be expected with direct poisoning, the question whether shyness can be developed to 1080, as it can to other poisons, is important. Kalmbach (1945) mentions that rats may develop an 'aversion' to 1080 solution. The field tests described here show that it is possible to induce shyness to 1080, as a result of its ingestion in a solid mixture. The fact that shyness was developed indicates that, when direct poisoning was unsuccessful, this was mainly due, not to a failure on the part of the rats to visit the baits, but to their failure to take a lethal amount.

One problem is whether there is any connexion between the success of direct poisoning with 1080 and the bait-base used. Of nine tests in which rusk was used, five (including two doubtful ones) were unsuccessful; one out of three tests with soaked barley was unsuccessful; but, of four tests with soaked wheat, all gave excellent results. It is impossible to say whether, in a longer series of tests with soaked wheat, a proportion of failures would be experienced. The fact that wheat grains may be hoarded by rats makes it in any case an unsuitable base for use with a dangerous poison.

Another problem is that of the percentage at which 1080 is used. It is possible, but far from certain, that higher percentages than 1·0 would give more consistent results. They would, of course, make the bait even more dangerous. The American workers have generally used lower percentages, but these would favour poison shyness. On the whole it seems improbable that further tests with the poison at different percentages would be profitable.

If it were proposed to recommend 1080 for general use, it would be necessary to do more tests. 1080 is, however, so dangerous that it is impossible to recommend its use on farms or in other places where domestic animals are kept, which at once greatly restricts its possible scope. Indeed, in the United States, where 1080 had been used on a large scale for general rat control, it is now recommended only in the hands of well-trained workers, and for use only in buildings such as warehouses to which few people have access (Ward, 1946; Simmons & Nicholson, 1947). These authors emphasize that 1080 is no panacea against rats.

There is clearly no advantage in using 1080 at all if the prebaiting method is to be followed, since less dangerous poisons are just as good. Further, the experiments reported here make it almost certain that 1080 used without prebaiting is less reliable than are zinc phosphide or antu with prebaiting. It follows that 1080 is not likely to be of general use unless there is an important class of rat infestations in which (*a*) 1080 can be used safely, (*b*) it is economically worth while to use direct poisoning and take the risk of some failures. The question whether these two qualifications apply to sewers is being studied separately.

If these conclusions are justified they have some general implications. The LD50 of 1080 to *R. norvegicus* is of the order of 4 mg./kg. or less. Even at this toxicity it is still capable of giving failures and of setting up poison shyness. This suggests that, to dispense with prebaiting, it is necessary to use a poison of at least this order of toxicity and preferably higher. But for such a poison to be safe, it must, unlike 1080, be relatively specific to the pests against which it is used. The obvious example of a relatively specific poison is scilliroside, the toxic glucoside of red squill, which is discussed in the following paper (Barnett, Blaxland, Leech & Spencer, 1949). In the absence of highly toxic, specific and palatable poisons, or of control methods based on different principles, it seems that for rat control we must still resign ourselves to the laborious method of prebaiting.

SUMMARY

1. Sodium fluoracetate (1080) has been tested in the field as a poison for *Rattus norvegicus* and *R. rattus*.

2. Direct poisoning (without prebaiting) was used in thirteen tests on *R. norvegicus*. In eight of these tests censuses showed kills of at least 89 %; in three tests the poison failed, and in two the results were equivocal.

3. Of three similar tests against *R. rattus* two were successful and one was a failure.

4. Six tests of 1080 after prebaiting gave five successes (including one against *R. rattus*), and one in which the estimated kill was about 82 %.

5. In five out of six tests populations of *R. norvegicus* which had survived baiting with 1080 showed shyness (refusal) of the poison when it was given in a new bait base.

6. The LD 50 of 1080 for a strain of white rats was found to be 3·8 mg./kg. (approx. range 2·8–5·2).

7. A number of wild birds and some domestic animals were accidentally killed during the tests despite stringent precautions taken in laying the bait and in warning occupiers.

8. It is concluded that:

(*a*) although 1080 is probably more effective in direct poisoning than other poisons used in the past, it does not give as consistent results as the standard poisons do after prebaiting;

(*b*) 1080 is too dangerous for general use.

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