J. Hyg., Camb. (1983), **91**, 351–357
Printed in Great Britain

Laboratory tests of seven rodenticides for the control of *Meriones shawi*

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(*Received* 18 *May* 1983; *accepted* 14 *June* 1983)

SUMMARY

The response of *Meriones shawi* to seven rodenticides was investigated in laboratory feeding tests. The species proved to be much less susceptible to anticoagulants than most other species of rodent pests. Brodifacoum (at 0·005 %), although giving complete mortality after only 8 days' continuous feeding, was more toxic than warfarin (0·025 %), coumatetralyl (0·0375 %), difenacoum (0·005 %) and bromadiolone (0·005 %). Calciferol (0·1 %), though toxic, was significantly unpalatable. Zinc phosphide (5·0 %) presented for 2 days in a choice test against unpoisoned food gave 80 % mortality and appears to be the most suitable of these compounds for the control of *M. shawi* in the field.

INTRODUCTION

Meriones shawi (Shaw's gerbil) is found in the coastal zone of North-west Africa from Morocco through Northern Algeria to Tunisia and Egypt (Corbet, 1978). The species has adapted to most ecological niches where there is sufficient depth of soil for its burrowing activities (Bernard, 1977). The breeding season is variable: in Tunisia, young are born throughout the year, with a peak in March and April, while in Morocco breeding starts in the winter and finishes early in the year at the beginning of the dry season (Giban & Haltebourg, 1965).

The economic importance of *M. shawi* is mainly due to its periodic population explosions, which have been recorded in Algeria, Morocco and Tunisia and are sometimes classed as national disasters (Bernard, 1977). The most serious economic damage caused by *M. shawi* is to cereal crops, where harvest losses of 40–70 % have been recorded. Besides eating crops in the field, large quantities of food are hoarded underground. One burrow may contain many kilos of fruit, bulbs and rhizomes, and tens of kilos of ears of cereals (Perret, 1961). Other crops damaged include lucerne, vines, olives, almonds, pistachos, henna, dates, pomegranates and garden vegetables (Giban & Haltebourg, 1965; Bernard, 1977; Hoppe, 1979). Young olive trees are damaged or killed by bark stripping and in very heavy infestations, the burrowing activities of *M. shawi* cause dessication of root systems leading to the death of older trees.

Control of *M. shawi* in the field is carried out mainly by the use of acute poisons (Bernard, 1977; Hoppe, 1979). Various rodenticides, including difenacoum and

brodifacoum have been tested against the species in the laboratory (Serrhini, 1978; Hoppe, 1979) but results have been very variable, possibly due to the use of non-standard test procedures. In order to clarify the response of *M. shawi* to a range of anticoagulants and other poisons, the investigation reported here was carried out using standard methods.

METHODS

The breeding colony from which the test animals were drawn consisted of 10 monogamous pairs provided by the Laboratoire de Recherches sur les Rongeurs Nuisibles, Marrakech. The colony was maintained on FFG(M) diet (Dixon & Sons, (Ware), Ltd) and water *ad lib.*

Feeding tests followed standard procedures (EPPO, 1975; WHO, 1982) and included toxicity tests where animals were given a sole diet of poisoned food for varying numbers of days, and palatability tests in which a choice between poisoned and plain foods was offered.

The bait used throughout the tests (except those with calciferol) consisted of medium grade oatmeal (95%) and wholemeal flour (5%). The relevant quantity of active ingredient was thoroughly mixed with the wholemeal flour, which was then added to the rest of the bait. In tests with calciferol, the wholemeal flour was replaced by a vegetable oil concentrate of the poison, and pinhead oatmeal was the main bait constituent. The other rodenticides were obtained as technical grade compounds, bromadiolone from Lipha (Lyon, France), warfarin, difenacoum, brodifacoum and calciferol from Sorex Ltd (Widnes), coumatetralyl from Bayer UK Ltd and zinc phosphide from BDH Chemicals Ltd.

RESULTS

Anticoagulants

The concentrations of anticoagulants used in the no-choice feeding tests were those which are normally recommended for rat and mouse control. The results of the tests with warfarin, coumatetralyl, bromadiolone and difenacoum (Table 1) show that these anticoagulants have a low toxicity at the concentrations tested. With 0·005% brodifacoum, the most active of the anticoagulant rodenticides (Table 2), 100% mortality was obtained after 8 days' feeding, with the time to death ranging from 4 to 12 days. When the data is subjected to probit analysis, the lethal feeding period (LFP) 50 and 99 values for brodifacoum are 4·8 days (95% fiducial limits 4·0–5·3) and 10·3 days (8·1–18·1) respectively.

Calciferol and zinc phosphide

The results of no-choice feeding tests with calciferol and zinc phosphide are shown in Table 3. Calciferol at 0·1% gave a 90% kill after 1–3 days' feeding and complete mortality after 4 days' feeding. In a 1-day test, zinc phosphide at 1·0% gave only 20% mortality, but at 2·0–5·0%, 70–100% mortality occurred.

Palatability tests were carried out on brodifacoum, calciferol and zinc phosphide, each against the same bait unpoisoned (Table 4). There was no discrimination against brodifacoum, but calciferol was significantly unpalatable ($P < 0·001$). In the tests with zinc phosphide, consumption of both poisoned and plain baits was

Table 1. *Results of no-choice feeding tests with four anticoagulants in medium oatmeal bait*

Poison and concentration	No. of days feeding	Sex	Mean body wt. (g)	Mortality	Survived dose of active ingredient (mg/kg) Mean	Range
Difenacoum	6	M	215	0/1	—	14·9
0·005%		F	155	0/1	—	14·1
	8	M	266	0/1	—	17·7
		F	180	0/1	—	16·6
	22	M	259	0/2	46·4	39·4–53·4
		F	166	1/2*	—	66·8
Warfarin	2	M	210	0/1	—	31·4
0·025%		F	194	0/1	—	34·9
	28	M	203	0/1	—	364
		F	192	0/1	—	451
Bromadiolone	21	M	211	0/2	60·9	58·2–63·5
0·005%		F	187	0/2	61·4	47·8–75·0
Coumatetralyl	15	M	212	0/2	220	219–221
0·0375%		F	141	0/2	354	251–458

* The lethal dose was 26·6 mg/kg and the days to death, 22.

very low, presumably because the poison acted quickly and prevented further feeding. The survival of eight animals on 2·0% and two on 5·0% zinc phosphide indicates that these individuals were able to detect the poison and thus avoid consuming a lethal dose.

DISCUSSION

The almost complete absence of mortality with warfarin, coumatetralyl, difenacoum and bromadiolone indicates that at standard concentrations these anticoagulants would be ineffective for controlling *M. shawi*. Serrhini (1978) obtained a 10/10 kill after three days feeding on 0·005% difenacoum; the bait contained mineral oil, which though known to increase the toxicity of anticoagulants in laboratory experiments, may do little to increase the effectiveness of these compounds in the field (Drummond & Wilson, 1968).

Although 0·005% brodifacoum proved more toxic than the other anticoagulants tested, the fact that 8 days' feeding was necessary to give a complete kill in the laboratory suggests that even this anticoagulant would give poor results in the field. This view is borne out by the degree of control (26·5–54·8%) obtained in five field trials carried out by Hoppe (1980). In laboratory tests, however, Hoppe (1980) obtained complete mortality with 0·005% brodifacoum (in wheat/corn oil bait) after 3 days' feeding. The animals used appear to have been sub-adult and it is not clear whether the work was done in strict accordance with the guidelines laid down by the European and Mediterranean Plant Protection Organization (EPPO, 1975). When we repeated this experiment with 10 animals using the same bait base as that used by Hoppe (1980), no mortality occurred.

The tolerance to brodifacoum and other anticoagulants shown by *M. shawi* is in striking contrast to the response of, for example, *Rattus norvegicus* (Redfern,

Table 2. *Results of no-choice feeding tests with* 0·005% *brodifacoum in medium oatmeal*

No. of days feeding	Sex	Mean body wt. (g)	Mortality	Lethal dose of active ingredient (mg/kg)		Survived dose of active ingredient (mg/kg)		Days to death	
				Mean	Range	Mean	Range	Mean	Range
3	M	265	1/10	—	9·4	7·0	5·8–10·1	—	6
	F	146	0/10	—		8·4	2·4–11·9	—	
4	M	190	3/5	12·8	6·9–17·4	10·9	8·3–13·5	9·3	8–10
	F	141	1/5	—	21·7	14·9	12·8–18·0	—	8)
5	M	229	3/5	12·5	10·8–15·1	12·0	10·9–13·1	9·0	7–10
	F	173	1/5	—	8·1	15·7	9·9–25·2	—	8)
6	M	206	3/5	11·0	10·2–11·7	19·0	16·9–21·1	12·3	10–14
	F	169	4/5	17·3	10·3–23·5	—	(21·9	9·5	7–14
7	M	171	5/5	18·5	13·6–21·8	—		11·0	7–15
	F	164	4/5	17·5	11·6–20·4	—	(18·5	9·5	8–12
8	M	136	5/5	17·5	5·5–28·0	—		9·0	4–12
	F	172	5/5	16·2	10·6–26·6	—		10·0	6–11

Table 3. *Results of no-choice feeding tests with calciferol and zinc phosphide*

Poison and concentration	No. of days feeding	Sex	Mean body wt (g)	Mortality	Lethal dose of active ingredient (mg/kg)		Survived dose of active ingredient (mg/kg)		Days to death	
					Mean	Range	Mean	Range	Mean	Range
Calciferol										
0·1 %	1	M	197	5/5	35·1	14·8–46·0	—			3
		F	159	4/5	32·2	25·0–42·2	–	12·3	4·0	3–5
	2	M	258	5/5	17·2	13·2–20·9	—		3·8	3–5
		F	166	4/5	18·9	12·6–32·9	—	15·0	7·5	3–19
	3	M	199	4/5	27·0	19·0–32·9	—	27·2	4·5	4–6
		F	148	5/5	43·8	26·4–64·2	—		5·2	4–9
	4	M	219	5/5	30·4	20·0–42·3	—		3·4	3–4
		F	153	5/5	48·5	12·9–94·1	—		4·0	3–5
Zinc phosphide										
1·0 %	1	M	244	2/5	57·9	41·0–74·7	37·5	15·4–61·5	1·5	1–2
		F	193	0/5	—		91·6	61·9–231·8	—	
2·0 %	1	M	199	5/5	144·6	74·4–230·7	—		1·4	1–3
		F	140	5/5	146·5	101·4–177·4	—		1·0	1
3·0 %	1	M	225	4/5	205·2	161·5–274·3	—	131·1	1·5	1–2
		F	176	4/5	226·3	95·6–431·4	—	192·3	1·0	1
4·0 %	1	M	200	4/5	277·8	223·6–337·3	—	104·4	1·5	1–2
		F	186	3/5	232·7	129·0–292·6	146·2	129·0–163·3	1·7	1–2
5·0 %	1	M	237	4/5	327·4	292·8–360·2	—	99·2	1·0	1
		F	177	5/5	322·6	186·2–598·2	—		1·0	1

Table 4. *Bait consumption in* M. shawi *given a choice between poisoned and plain baits*

Poison and concentration	Mean body wt (g)	Duration of tests (days)	Mean daily bait intake (g)		No. of animals preferring poison	Significance (P) of Student's 't'	Mortality
			Poison	Plain			
Brodifacoum 0·005 %	180	4 (2)*	8·6	8·3	6/10	> 0·5	0/10
Calciferol 0·1 %	192	2 (1)	1·2	5·3	0/10	< 0·001	0/10
Zinc phosphide							
2·0 %	221	2 (1)	0·48	1·97	4/10	> 0·1	2/10
5·0 %	218	2 (1)	0·69	0·72	5/10	> 0·5	8/10

* Figures in parenthesis indicate number of days for which figures of bait consumption used in calculations.

Gill & Hadler, 1976) and other rodent species. It is perhaps significant that the only other species known to be tolerant to brodifacoum, the Egyptian spiny mouse (*Acomys cahirinus*) (Mahmoud & Redfern, 1981) is also an inhabitant of hot and arid environments.

Calciferol at 0·1 % was toxic, but significantly unpalatable. The consumption of poisoned food dropped markedly after the first day, suggesting that poison shyness might be a problem in the field.

The laboratory tests with zinc phosphide reported here and the satisfactory control (71·3–94·7 %) obtained in field trials using the active ingredient at 3·0 % (Hoppe, 1980) indicate that this poison is probably the most effective of those tested for controlling *M. shawi* under practical conditions.

We are indebted to Mr A. Hoppe of the Laboratoire de Recherches sur les Rongeurs Nuisibles, Marrakech, for supplying the original stock of *M. shawi*, Mrs C. Burns for managing the breeding colony, and Mr J. Chaproniere for assisting with the laboratory work.

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