J. Hyg., Camb. (1980), 85, 421
Printed in Great Britain

Laboratory evaluation of anticoagulant-treated baits for control of the northern palm squirrel, *Funambulus pennanti* Wroughton

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(*Received* 19 *May* 1980)

SUMMARY

Individually caged northern palm squirrels, *Funambulus pennanti*, were fed with bait containing 0·025% warfarin or fumarin, 0·0075% chlorophacinone or 0·005% brodifacoum for a fixed number of days varying from 1 to 14. Brodifacoum (WBA 8119) was found most toxic since 66% and 70% of the animals died after one and two days' feeding respectively. Chlorophacinone killed 70% of the squirrels after three days' feeding. Squirrels were relatively tolerant to warfarin and fumarin since the mortality after a period of 14 days' feeding was only 58% and 75% respectively.

INTRODUCTION

The northern palm squirrel, *Funambulus pennanti*, is distributed in northern India, Baluchistan, Sind, Nepal and Iran. It has been recognized as a serious pest of vegetable crops, orchards and gardens (Barnett & Prakash, 1975). It also feeds on insects which are commercially valuable (Krishnaswami & Chauhan, 1957). In spite of the well-established role of the northern palm squirrel as an agricultural pest in India, very little work has been done to control it. Anticoagulant-treated baits are used extensively for the control of ground squirrels in California (Clark, 1978). They are also reported to be effective against three field rodents of south Asia (Greaves & Rehman, 1977). We now report on a laboratory evaluation of four anticoagulant rodenticides against *F. pennanti*.

METHODS

Funambulus pennanti were captured at Jodhpur (Lat. 26° 18′ N, Long. 73° 01′ E), using live traps. The animals were caged individually in the laboratory and were acclimatized for two weeks before the initiation of the experiments. Equal numbers of males and females were taken for each experiment. Sick animals and pregnant females were discarded. After acclimatization, the animals were provided with anticoagulant-treated baits for a fixed number of days. The consumption of poisoned bait was recorded and freshly prepared bait was provided daily.

0022-1724/80/0047-1980 $01.00

Symptoms and time to death were recorded and the dead animals were autopsied to confirm the signs of anticoagulant poisoning. Water was available *ad libitum* throughout the experiments.

The chronic rodenticides evaluated were warfarin (3-(1-phenylethyl-2-acetyl) 4-hydroxycoumarin), fumarin (3-(1-furfuryl-2-acetyl-furfuryl) 4-hydroxycoumarin), chlorophacinone (2-1 (P-chlorophenyl-1-phenyl acetyl)-1,3,indandione) and brodifacoum or WBA 8119 (3-(3-4'-bromo)1-1' diphenyl) 4-yl-1,2,3,4-tetrahydro-1-naphthalenyl)-4-hydroxy-2H-1-benzopyran-2-one.

Chlorophacinone was obtained as a commercial ready-to-use 0·0075% bait (maize based). Warfarin and fumarin were obtained as 0·5% commercial pre-mixes which were mixed with whole millet at the ratio of 1:19 giving a 0·025% concentration in the bait. Whole millet mixed with a 0·1% brodifacoum pre-mix provided a 0·005% brodifacoum-treated bait.

The trials were conducted in accordance with the method for determining the susceptibility of rodents to anticoagulant rodenticides provisionally recommended by W.H.O. (1970). Median lethal feeding period (LFP 50) and 95% fiducial limits were calculated according to Finney (1971).

RESULTS AND DISCUSSION

The data indicate that 100% mortality was attained by feeding brodifacoum and chlorophacinone for six and seven days respectively (Tables 1 and 2). Combined sex mortality data reveal that the median lethal feeding period (LFP 50) and 95% fiducial limits for brodifacoum are 1·1 days and 0·7–2·0 days; for chlorophacinone 2·2 days and 0·7–3·8 days; for warfarin 7·7 days and 4·0–14·5 days; and for fumarin 7·2 days and 1·7–21·7 days respectively. For warfarin and fumarin the time to death increased with the increase in length of the feeding period. However, this trend was not evident with brodifacoum. With chlorophacinone the time to death usually decreased with the increasing length of feeding periods.

Of the four anticoagulants evaluated, brodifacoum was the most toxic for *F. pennanti* next followed by chlorophacinone. The percentage kill due to warfarin and fumarin feeding for 7 and 14 days did not differ significantly (Tables 3 and 4) and only 58% and 75% of squirrel were killed by these two poisons respectively. Such differences in response to various anticoagulants have also been reported by Marsh, Shaw & Wetherbee (1964) who found that prolin-, warfarin- and fumarin-treated baits were not effective for the ground squirrel, *Spermophilus beecheyi*, in California in comparison with diphacinone and pival.

The amounts consumed of all four anticoagulant baits by both dead and surviving squirrels reveal that there was no apparent decline in the intake during the 1–14-day feeding period. It is thus apparent that no tolerance to these anticoagulants was induced during this short time. However, brodifacoum has an edge over the other three anticoagulants because 66% of the squirrels died after only a single day's feeding. Brodifacoum has also been reported effective against many rodent species including warfarin-resistant strains (Dubock & Kaukeinen, 1978).

So far, in India only warfarin and fumarin are being used among anticoagulants

Table 1. *Toxicity of* 0·005% *brodifacoum to* Funambulus pennanti

Feeding period (days)	Body wt (g) Mean ± S.E.	Poisoned bait consumed (g) Mean ± S.E.		Brodifacoum consumed (mg/kg) Mean ± S.E.		Mortality	Days to death	
		Died	Survived	Died	Survived		Mean	Range
1	102·02 ± 4·43	6·77 ± 0·59	6·87 ± 1·30	3·06 ± 0·48 (1·81 – 5·92)	3·08 ± 0·56 (2·0 – 4·40)	8/12	7·6	6–12
2	102·51 ± 2·87	10·50 ± 1·25	11·4 ± 4·0	4·64 ± 0·59 (2·83 – 7·25)	4·71 ± 1·88 (0·95 – 6·69)	7/10	7·5	5–13
4	99·29 ± 3·10	21·93 ± 2·16	7·69	10·26 ± 1·03 (3·29 – 13·71)	3·61	9/10	9·7	6–20
6	82·13 ± 6·28	37·55 ± 3·23	—	19·66 ± 2·03 (5·71 – 33·55)	—	12/12	8·7	4–13

Table 2. *Toxicity of* 0·0075% *chlorophacinone to* Funambulus pennanti

Feeding period (days)	Body wt (g) Mean ± S.E.	Poisoned bait consumed (g) Mean ± S.E.		Chlorophacinone consumed (mg/kg) Mean ± S.E.		Mortality	Days to death	
		Died	Survived	Died	Survived		Mean	Range
1	103·59 ± 3·81	11·17 ± 1·98	5·71 ± 1·56	7·42 ± 1·62 (4·17 – 11·85)	4·12 ± 0·93 (1·0 – 7·0)	4/10	10·7	9–12
3	78·13 ± 3·85	26·41 ± 2·22	17·94 ± 4·92	24·13 ± 2·37 (15·58 – 32·56)	25·28 ± 4·29 (7·93 – 29·56)	7/12	8·4	5–12
5	96·57 ± 10·05	34·28 ± 6·34	29·36 ± 8·64	29·80 ± 7·32 (3·06 – 68·0)	21·31 ± 6·54 (4·88 – 35·92)	8/12	7·6	2–14
7	95·71 ± 3·0	24·99 ± 3·50	—	24·8 ± 1·82 (10·0 – 32·0)	—	12/12	8·1	6–12

Table 3. *Toxicity of* 0·025 % *warfarin to* Funambulus pennanti

Feeding period (days)	Body wt (g) Mean ± S.E.	Poisoned bait consumed (g) Mean ± S.E.		Warfarin consumed (mg/kg) Mean ± S.E.		Mortality	Days to death	
		Died	Survived	Died	Survived		Mean	Range
1	93·36 ± 3·07	—	6·44 ± 0·47	—	17·10 ± 1·57 (10·60 – 26·73)	0/10	—	—
5	89·67 ± 7·15	28·00 ± 0·69	31·38 ± 3·16	74·32 ± 6·57 (67·60 – 87·42)	93·02 ± 12·74 (45·05 – 158·67)	3/12	5·6	5–6
7	101·72 ± 2·78	22·52 ± 1·67	32·48 ± 2·78	65·00 ± 7·29 (39·00 – 1000·00)	69·20 ± 6·72 (54·00 – 83·00)	7/12	7·3	6–9
14	99·25 ± 3·81	40·77 ± 7·80	71·36 ± 6·25	102·50 ± 18·84 (46·78 – 188·00)	185·59 ± 35·59 (129·00 – 250·00)	7/12	8·1	4–13

Table 4. *Toxicity of* 0·025 % *fumarin to* Funambulus pennanti

Feeding period (days)	Body wt (g) Mean ± S.E.	Poisoned bait consumed (g) Mean ± S.E.		Fumarin consumed (mg/kg) Mean ± S.E.		Mortality	Days to death	
		Died	Survived	Died	Survived		Mean	Range
1	103·05 ± 0·93	—	5·15 ± 0·43	—	11·83 ± 1·08 (4·39 – 15·99)	0/10	—	—
5	89·08 ± 3·32	35·33 ± 6·94	34·80 ± 3·46	98·43 ± 14·30 (71·76 – 129·10)	97·45 ± 10·10 (40·59 – 137·88)	4/12	4·7	3–6
7	75·91 ± 4·05	36·08 ± 4·38	43·30 ± 10·68	124·30 ± 15·58 (35·00 – 191·00)	152·33 ± 13·30 (129·00 – 175·00)	9/12	7·0	2–14
14	104·64 ± 2·90	67·00 ± 5·59	82·43 ± 5·41	165·12 ± 15·43 (90·35 – 234·39)	186·67 ± 16·64 (159·65 – 216·90)	9/12	13·5	7–19

for rodent control. The introduction of brodifacoum would not only reduce the cost of poison bait but, if it is as effective in field trials as the above experimental results indicate, it would also effect a huge saving of food grain required for field trials of warfarin and fumarin.

We have also tried chlorophacinone for the control of seven species of rodents (Mathur & Prakash, 1979; Prakash & Mathur, 1979). It was also found to be quite effective against *F. pennanti*.

Zinc phosphide is being used extensively in India for the control of field rodents. It induces shyness among a number of field rodents even after a single exposure (Prakash & Jain, 1971; Prakash, Rana & Jain, 1975). The results of the present study suggest that brodifacoum and chlorophacinone can be used effectively for the control of *F. pennanti*. The findings have wider application also. Under the National Programme for Rodent Pest Management in vogue in India, the burrows of field rodents are fumigated with aluminium phosphide after zinc phosphide baiting. Fumigation is never very successful for several reasons, besides being fairly expensive. Brodifacoum and chlorophacinone baiting can replace the fumigation step in the National Programme. This recommendation will, however, depend on the results of more field trials.

We are indebted to Dr H. S. Mann, Director of the Central Arid Zone Research Institute, Jodhpur, where the work was carried out. It is our pleasure to thank Dr J. H. Greaves of PICL, Tolworth, Surrey, for criticizing the manuscript and making useful suggestions. Dr G. V. S. Ramakrishna helped in statistical analysis; the authors are grateful to him. The chemicals were supplied by: warfarin (Pest Control) (India) Pvt. Ltd, Bombay, fumarin (Agromore Ltd, Bangalore), chlorophacinone (Reanal Factory, Budapest) and brodifacoum (ICI, United Kingdom); our grateful thanks are due to them.

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