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Evaluation of warfarin against *Tatera indica* and *Meriones hurrianae*

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Abstract. Warfarin was evaluated in laboratory against Indian gerbil, *Tatera indica* and desert gerbil, *Meriones hurrianae*. Chronic LD_{50} for the two species was found to be $4 \times 19{\cdot}1$ and $4 \times 15{\cdot}9$ mg/kg respectively. Feeding for 14 days on 0·025% warfarin treated bait provided complete kill in the gerbils but the poisoned bait was less palatable than the plain bait. A period of 18 and 19 days feeding on 0·025% warfarin bait was found suitable to detect resistance to warfarin among *T. indica* and *M. hurrianae* respectively.

Keywords. *T. indica*; *M. hurrianae*; oral toxicity; no-choice tests; base-line susceptibility; palatability; warfarin.

1. Introduction

The Indian gerbil, *Tatera indica* Hardwicke and the desert gerbil, *Meriones hurrianae* (Jerdon) are dominant rodent species in the Indian desert and inflict severe damage to crops and grasslands (Barnett and Prakash 1975). Since they induce bait shyness after a single exposure of zinc phosphide (Prakash and Jain 1971) the need to evaluate other rodenticides as alternative poisons for their control has arisen. The present study was, therefore, undertaken to evaluate warfarin [3–(1-phenylethyl-2 acetyl) 4-hydroxy-coumarin] against *T. indica* and *M. hurrianae*.

2. Material and methods

The gerbils were captured from fields around Jodhpur (Lat. 26° 18′ N ; Long. 73° 1′ E). They were sexed, weighed and caged individually for 3 weeks for acclimatization and were fed on bajra (*Pennisetum typhoides*) and jowar (*Sorghum vulgare*). Average body weights of *T. indica* and *M. hurrianae* (g ; mean ± SE) were $124{\cdot}16 \pm 5{\cdot}73$ and $62{\cdot}44 \pm 3{\cdot}62$ respectively. Each of the four doses (5·0, 15·0, 25·0 and 50·0 mg/kg) of technical warfarin of 98% purity was administered by oral tube for four consecutive days to calculate the chronic LD_{50}. No-choice and choice feeding trials were conducted using 0·0125% and 0·025% warfarin-

treated bajra grains. The former trials were conducted for different lengths of feeding periods. In choice tests an alternative unpoisoned bait was also provided to the gerbils. The trials were conducted as recommended by WHO (1976) and the $LD_{50's}$, lethal feeding periods (LFP_{50} and LFP_{98}) and their 95% confidence limits were calculated by probit analysis (Finney 1971).

3. Results

Sex difference in the mortality was not observed in any of the trials and hence combined sex mortality data were analysed.

3.1. *Oral toxicity*

Chronic LD_{50} and 95% confidence limits for *T. indica* and *M. hurrianae* are $4 \times 19{\cdot}1$ ($13{\cdot}8$–$27{\cdot}61$) and $4 \times 15{\cdot}9$ ($11{\cdot}0$–$24{\cdot}0$) mg/kg respectively. Slopes of the probit regression line with respect to two species are $1{\cdot}48 \pm$ S.E. $0{\cdot}12$ and $1{\cdot}61 \pm 0{\cdot}12$ respectively.

3.2. *No-choice tests*

In no-choice feeding tests complete kill was observed with 14 days feeding on $0{\cdot}0125$ and $0{\cdot}025$% warfarin treated bait in both the species (table 1) except that with the former concentration one *T. indica* survived.

In both the gerbils, *T. indica* and *M. hurrianae*, mortality started from day 4 and 5 and lasted upto days 18 and 16 respectively and maximum kill occurred between 5 to 10 days (table 1). Bait intake in no-choice test was fairly high upto 6–7 days after which it declined possibly due to the development of the symptoms of anticoagulant poisoning.

3.3. *Base-line susceptibility*

Table 2 gives the lethal feeding periods (LFP_{50} and LFP_{98}), their 95% confidence limits and slopes of the probit regression lines. The slope of the probit regression line and LFP_{50} does not differ significantly between the sexes and concentration but significant difference was found between species ($P < 0{\cdot}02$) with respect to $0{\cdot}025$% concentration (table 2) which indicates that *M. hurrianae* is more susceptible to warfarin than *T. indica.*

3.4. *Acceptability of poisoned bait*

Poisoned bait was less palatable than the plain bait (table 3). The difference was not significant between the two concentrations in both the species. However, with both the concentrations the intake of poisoned bait by *M. hurrianae* was significantly more ($P < 0{\cdot}01$) than *T. indica* (table 3) and hence the mortality was higher in the former species.

Table 1. Mortality in *T. indica* and *M. hurrianae* feeding on warfarin-treated pearl millet in no-choice tests.

Feeding period (days)	Conc. of poison (percent)	Anticoagulant consumed (mg/kg), Mean ± S.E.		Mortality	Days to death	
		Died	Survived		Mean	Range
		Tatera indica				
2	0·0125	...	14·36±0 ·84	0/10	...	...
4		24·48± 3·78	26·06± 2·56	2/10	4·5	4–5
7		42·38± 5·43	46·98± 5·20	6/10	10·0	7–13
10		41·70± ·57	65·38	9/10	9·1	5–12
14		39·16± 4·07	81·25	11/12	8·2	5–11
2	0·025	38·65	21·30± 2·17	1/10	18·0	...
4		41·61±11·23	56·80± 3·17	4/10	5·2	5–6
7		104·16± 5·51	108·83± 6·67	6/12	6·6	4–8
10		72·20± 3·99	60·75	9/10	8·5	7–13
14		86·27± 9·23	...	12/12	8·6	5–14
		Meriones hurrianae				
2	0·0125	22·32	19·98± 2·24	1/10	11·0	...
4		28·17± 2·36	22·47± 5·90	4/10	6·7	5–10
7		79·40± 9·43	80·67± 7·19	6/10	7·3	4–11
10		85·45±14·60	99·95± 2·65	7/10	9·7	6–15
14		96·46± 9·96	...	10/10	10·5	7–15
2	0·025	21·51	30·58± 4·06	1/10	6·0	...
4		47·22± 8·40	57·56± 5·37	5/10	5·6	4–7
7		114·10±14·95	103·57±23·45	8/12	8·4	5–12
10		114·41±21·59	148·83±16·18	8/10	8·1	5–14
14		173·16±16·98	...	10/10	11·4	5–16

Table 2. Lethal feeding periods (LFP) for *T. indica* and *M. hurrianae* and their 95% fiducial limits using warfarin.

Species	Conc. of poison (percent)	Slope of the probit regression line (b) ± S.E.	LFP_{50} (days)	LFP_{98} (days)
T. indica	0·0125	1·92±0·10	6·0 (4·4–8·1)	16·6 (8·9–30·9)
	0·025	1·13±0·08	5·7 (4·2–7·9)	13·2 (10·0–17·4)
M. hurrianae	0·0125	1·81±0·07	4·6 (3·8–5·7)	13·5 (10·0–18·2)
	0·025	1·89±0·08	3·7 (2·8–4·7)	12·9 (9·1–18·2)

Table 3. Bait acceptability and mortality in *T. indica* and *M. hurrianae* given 'choice' between plain and warfarin-treated bait.

Concentration of poison (per cent)	Duration of test (days)	Mean daily bait intake (g/100 g body wt) Mean ± S.E.		Significance of student's 't' between 1 and 2	Mortality	Days to death Mean (range)
		Poison (1)	Plain (2)			
		Tatera indica				
0·025	14 (2)	1·95±0·35	4·21±0·41	0·001	6/12	11·3 (5–19)
0·0125	14 (2)	2·48±0·45	4·20±0·59	0·05–0·02	5/12	9·4 (4–14)
		Meriones hurrianae				
0·025	14 (2)	5·46±0·98	7·16±1·07	0·30–0·20	11/12	9·7 (5–15)
0·0125	14 (2)	4·07±0·76	6·94±0·81	0·02–0·01	8/12	6·1 (4–16)

(Figures in parenthesis indicate the number of days for which bait consumption data were analysed.)

4. Discussion

Our data on toxicity of warfarin against *T. indica* are fairly comparable with that of Greaves and Rehman (1977) in as much as that complete kill was achieved in 14 days feeding on 0·025% warfarin. Comparing the suceptibility of warfarin to gerbils with that of other species it is revealed that they are less susceptible than *R. norvegicus* (Bentley and Larthe 1959 ; Brooks and Bowerman 1974) and *Bandicota bengalensis* (Deoras 1967 ; Greaves and Rehman 1977 ; Sridhara 1979 ; Brooks *et al* 1980).

The two gerbils under study are also less susceptible than *Arvicanthis niloticus* where 6 days feeding on 0·025% warfarin produced 100% kill (Gill and Redfern 1977). Mukthabai and Krishnakumari (1976) reported 100% kill in *R. rattus* in 7 days, in the same period Mathur and Prakash (1981a) achieved 92% kill, whereas Krishnamurthy *et al* (1968) and Chaturvedi *et al* (1975) observed 100% kill in 13 days. Similar results are also obtained with *Rattus argentiventer* where 10–12 days feeding is required to kill all experimental animals (Buckle *et al* 1980) and *Mastomys natalensis* giving complete kill in 13 days (Gill and Redfern 1979). However, the northern palm squirrel, *Funambulus pennanti*, was found fairly less susceptible to warfarin as compared to the two gerbils where even 14 days feeding could not kill more than 58% squirrels (Mathur and Prakash 1980). *Mus musculus* also required 28 days of feeding on 0·025% warfarin-treated bait for

complete kill (Rowe and Redfern 1964). Significant difference was not observed in the mortality among the two gerbils when the two concentrations, 0·0125% and 0·025% of warfarin were used and hence the former is recommended for the control of *T. indica* and *M. hurrianae*.

Taking the upper 95% confidence limits of LFP_{98} (precluding 0·0125% concentration) the data suggest that feeding on 0·025% warfarin for 18 and 19 days would be suitable to test resistance to warfarin among *T. indica* and *M. hurrianae* respectively. This period is quite comparable with that for *T. indica* (21 days) reported by Greaves and Rehman (1977), *R argentiventer* (18 days, Buckle *et al* 1980) and cotton rat, *Sigmodon hispidus* (20 days, Gill and Redfern 1980). However, *B. bengalensis* (8 days ; Brooks *et al* 1980) and *R. norvegicus* (7 days; Brooks and Bowerman 1974) are more prone to develop resistance to this poison than the gerbils. Greaves and Rehman (1977) also reported that *Tatera* has the potential to develop a significant degree of resistance to anticoagulants than *R. rattus* which requires 28 days feeding on 0·025% warfarin as a suitable test for resistance. It is evident that warfarin provides good results against a number of species but it requires longer period of feeding than brodifacoum and chlorophacinone (Mathur and Prakash 1981b, 1982).

The widespread use of such poison as the sole mean to control gerbils and other rodent pests for a considerable period can eventually lead to pockets of warfarin-resistant animals which is a serious problem in most of Europe and United States of America. It is, therefore, recommended that intermittently other poisons which kill rodents in shorter time should also be used.

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