Cumatetralyl as an avicide for use against the Cape sparrow

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The potential of cumatetralyl, an anticoagulant, for controlling the Cape sparrow *Passer melanurus* (Statius Müller), and its secondary poisoning hazards to carnivorous vertebrates were investigated under captive conditions. The LD_{50}-value for the Cape sparrow was about 140 times higher than the value reported for the laboratory rat. It is concluded that cumatetralyl is not a suitable agent for use against the Cape sparrow, and that it would constitute a secondary poisoning hazard to predators.

Birds cause severe damage to deciduous fruit crops in the south-western Cape, South Africa, estimated at some R2 million annually for table-grapes alone (J. Deist *in litt.* 1982). The Cape sparrow *Passer melanurus* (Statius Müller) appears to be by far the most important problem bird in this agricultural region, and table and wine grapes are the crops most severely depredated (Heÿl 1978, Swart & Flight 1982).

Numerous methods of controlling or repelling problem birds have been applied in the region with variable success (Swart & Flight 1982). Recently certain farmers found indications that an anticoagulant known as cumatetralyl (3 (a – tetralyl)- 4 - hydroxycoumarin) had potential for controlling the Cape sparrow. This poison is registered in South Africa as a rodenticide and is marketed under the trade-name "Racumin Liquid Rat Poison (Bayer)". In an endeavour to find a more effective and acceptable control method, the Western Cape Society for the Production of Table Grapes requested the Department of Agriculture to investigate the registration of "Racumin" as an avicide.

Resultant trials by Giliomee (1982) showed that Cape sparrows die when kept solely on a ration of white bread poisoned with cumatetralyl, indicating some toxic properties for birds. The Cape Department of Nature and Environmental Conservation was subsequently approached for a recommendation regarding the registration of Racumin for use against the Cape sparrow, although test results by the manufacturers of Racumin indicated that it was not an effective avicide (Hermann & Hombrecher 1962, Anon. 1968, G. Hermann *in litt.* 1982).

In view of a general concern about the indiscriminate use of poisons and their imminent dangers to non-target species, this study was initiated to determine the efficiency of cumatetralyl as an avicide for the Cape sparrow under controlled conditions, and to investigate potential secondary poisoning hazards to carnivorous vertebrates.

METHODS

Cape sparrows were captured with two funnel traps (1,2 x 0,9 x 1,0 m), baited with mixed chicken-grain and wild bird-seed, on the Nietvoorbij Experimental Farm, Stellenbosch, from 12 to 25 January 1983. Birds were kept in a large aviary (31 x 9 x 3 m) for at least eight days to adapt to captive conditions. Mixed chicken grain and wild bird-seed were supplied *ad libitum*, and white bread soaked in water was given daily. Fresh water and sufficient roosting sites were provided.

A section of the aviary was partitioned off (12 x 9 x 3 m) immediately before the start of the first trial. Ten birds (four males and six females) were guided into this section. Following a one-day period to adapt to these conditions, the group was fed predetermined experimental rations consisting of unpoisoned water-soaked white bread and a commercially available wild bird-seed mixture *ad libitum* for a four-day trial period to determine their preference for these food types. The latter consisted of a mixture of 80% red and yellow manna *Setaria italica*, and 5% of babala *Pennisetum typhoides*, canary seed *Phalaris canarienses*, wild canary seed *P. minor* and millet *Panicum miliaceum* respectively. The daily ration was one slice of bread of about 100 g, and 200 g of wild bird-seed, both measured to the nearest 0,01 g. Fresh water was also provided. The bread and the seed mixture were put out in two separate round containers (180 x 70 mm). Fresh food was provided daily at 12h00 and all remains in the containers were removed at the same time, oven-dried at 80°C to a constant mass, and weighed. Observations indicated that little wastage occurred other than leftovers in the containers. Separate samples of the bread and seed mixture were taken daily, oven-dried and the ratio of fresh to oven-dried mass determined as a basis for calculating the quantities of oven-dry food consumed by the experimental group.

Immediately following the food preference trial the same ten birds were subjected to cumatetralyl-poisoned white bread. "Racumin Liquid Rat Poison" with an active ingredient of 0,8% mv^{-1} (= 8 g l^{-1}) was diluted at a ratio of 50 ml to 700 ml of water, i.e. a concentration of 0,533 g active ingredient per litre was applied. The bread was carefully and completely saturated with this solution, and any excess poison was decanted in order to determine the precise quantity used. The same procedures and rations as for the above trial were otherwise used. Untreated wild bird-seed was therefore also available. The daily quantities of poison taken by the

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birds were calculated from their consumption of bread, assuming a homogeneous distribution of the solution. Dead sparrows were removed daily and the trial extended until all birds were dead.

The remaining sparrows were guided into the smaller section of the aviary in groups of 15–40 birds every 2–4 days. White bread saturated with the cumatetralyl solution was provided daily and any remnants of the previous day were removed. Both the poisoned bread and untreated wild bird-seed were available *ad libitum*. Dead birds and those still alive but severely affected by the poison were removed daily at 08h00 and 16h00, and fed to four species of test subjects for determining secondary poisoning hazards. Excess carcases were placed in a refrigerator and used within 24 hours following collection. Test subjects consisted of one feral domestic cat *Felis catus,* two male laboratory rats *Rattus norvegicus,* one steppe buzzard *Buteo buteo* and one spotted eagle owl *Bubo africanus*. The domestic cat and birds of prey were kept in separate outdoor cages (3 x 1 x 2 m), and the two rats together in an indoor cage (0,6 x 0,4 x 0,3 m). Body masses of these animals were determined after completion of the experiments, and post-mortem examinations were carried out on those which succumbed.

RESULTS

A total of 413 Cape sparrows were captured over 13 days, at a median trapping rate of 13 birds per trap-day, and a maximum of 64.

Body masses of 20 males and 24 females were determined to the nearest 0,01 g within one hour following removal from the trap. The mean body mass of males ($\bar{x}$ = 27,07 g; S.D. = 2,13 g) was not significantly different from that of females ($\bar{x}$ = 26,27 g; S.D. = 1,49 g) for this limited data set (P > 0,05), and the combined mean body mass ($\bar{x}$ = 26,64 g; S.D. = 1,83 g) was therefore calculated.

TABLE 1

Comparative consumption of water-soaked white bread and wild bird-seed by ten captive Cape sparrows.

Day	Oven-dry mass consumed per bird per day (g)			Bread as % of Total
	Unpoisoned bread	Seed	Total	
1	1,725	4,174	5,899	29,24
2	2,543	5,043	7,586	33,52
3	2,070	3,983	6,053	34,20
4	2,068	3,309	5,377	38,46
Mean	2,102	4,127	6,229	33,86

The food preference trial indicated that wild bird-seed was preferred to white bread at a ratio of about 2:1, and that the mean combined daily consumption was 6,2 g oven-dry food per bird (Table 1). These data formed a basis for evaluating the results obtained with the subsequent trial on the toxicity of cumatetralyl for the Cape sparrow.

Primary toxicity:

Both qualitative and quantitative changes in food consumed by the experimental group of sparrows were observed after treatment of the bread with cumatetralyl (Table 2). Total food consumption per bird per day during the first four days of the primary toxicity test was not significantly lower than that observed during the preceding food preference trial (P > 0,05). Consumption progressively decreased from the fifth day, a trend indicated by the negative slope of a linear regression line fitted to the complete data set (r^2 = 0,73; P < 0,001). The mean daily consumption was therefore significantly lower during the toxicity test, when compared with results for the food preference trial (P < 0,05).

Consumption of cumatetralyl-treated bread, for the first day of the toxicity test, dropped to 34% of that observed previously. This decrease was significant (P < 0,01), as was the lower mean daily bread consumption for the full duration of this trial (P < 0,05). However, following the initial drop, bread consumption per bird increased throughout the toxicity test (r^2= 0,66; P< 0,01), which inevitably also resulted in exposure to larger quantities of cumatetralyl (r^2= 0,79; P < 0,001).

Although somewhat higher, the mean consumption of wild bird-seed during the first four days of the toxicity test did not differ significantly from that observed previously (P > 0,05). However, a drastic decrease in seed consumption was noted over the full extent of the toxicity test (r^2 = 0,90; P < 0,001). From the above it is clear that a negative correlation existed between the consumption of bread and seed, which is described by the exponential function $y = 12,5\ e^{0,18x}$, where x is the day of the trial, and y the daily percentage of bread consumed. This function with a high coefficient of determination of 0,92 indicates that the correlation was

TABLE 2

The feeding behaviour of ten Cape sparrows subjected to cumatetralyl poisoning.

Day	Number of bird-days	Oven-dry mass consumed per bird per day (g)			Bread as % of Total	Quantity of diluted poison taken (m*l*)	
		Poisoned bread	Seed	Total		Total	per bird-day
1	10,0	0,709	5,064	5,773	12,28	14,87	1,487
2	10,0	1,152	4,616	5,768	19,97	23,24	2,324
3	9,5	1,306	4,209	5,515	23,68	26,81	2,822
4	7,5	1,400	4,105	5,505	25,43	20,78	2,771
5	5,5	1,149	2,727	3,876	29,64	12,51	2,275
6	4,5	1,218	2,760	3,978	30,62	14,05	3,122
7	3,5	1,234	1,343	2,577	47,89	12,24	3,497
8	2,5	1,516	1,320	2,836	53,46	9,88	3,952
9	1,5	1,913	1,187	3,100	61,71	9,10	6,067
10	1,0	1,450	0,060	1,510	96,03	4,16	4,160
11	0,5	2,320	1,360	3,680	63,04	3,17	6,340

not linear, and that the birds progressively changed to a diet of treated bread.

The first bird of the experimental group of ten died during day three and the last during day eleven. No special attention was given to bird behaviour during the experiment. It was noted, however, that shortly before death two of the sparrows stayed inactive with fluffed-out body feathers while closely approached by the observer. On other occasions the flying ability of two birds was clearly influenced. No such observations were recorded for the c.400 sparrows in the adjoining section of the aviary, indicating that the experimental group died as a result of exposure to cumatetralyl.

Half the birds were dead after 5,5 days, in which time an estimated 105,2 m*l* of the diluted toxicant was taken by the group. The combined body mass of the group of ten sparrows was estimated at 266,4 g, assuming the above mass of 26,64 g per wild-caught bird. It was therefore calculated that 210,7 mg active ingredient per kilogram live mass killed 50% of the experimental group, giving an approximate LD_{50}-value of 5,5 x 38,3 mg kg $^{-1}$. Hundred percent mortality was obtained after a total of 150,8 m*l* of the diluted toxicant (= 301,9 mg active ingredient per kilogram live mass) was taken over 10,5 days, estimating the LD_{100} as 10,5 x 28,8 mg kg^{-1}.

Secondary toxicity hazards:

Body masses of 35 poisoned sparrows still alive when collected, and of 96 dead birds, were determined. Analyses of variance indicated that no significant differences for the respective sexes existed between the mean body mass of birds collected when still alive and those already dead, nor had the time of collection, i.e. 08h00 or 16h00, any influence on the observed masses ($P > 0,05$). However, the mean body mass of males ($\bar{x}$ = 25,88 g; n = 62; S.D. = 2,21 g) was significantly higher ($P < 0,001$) than that of females ($\bar{x}$ = 24,37 g; n = 69; S.D. = 2,43 g). The body masses of poisoned males were on average 4,4% ($P < 0,05$) and females 7,2% ($P < 0,001$) lower compared with masses taken directly following field capture. However, it is likely that poisoning would eventually affect food intake, and these small discrepancies were probably merely the result of smaller quantities of food in the alimentary canal of poisoned birds. Indications therefore are that the sparrows were physiologically well-adapted to the captive conditions, and that they died as a result of cumatetralyl poisoning. The carcases were consequently considered suitable material for testing the hazards of secondary poisoning.

The sex of poisoned sparrows fed to the subjects of the secondary poisoning trials was not distinguished. The body mass of poisoned sparrows, assuming an equal sex ratio ($P > 0,05$; n = 131), was therefore taken as the mean for the two sexes combined, i.e. 25,12 g.

The domestic cat died after consuming 79 poisoned birds over 14 days (Table 3). Sparrow carcases were devoured almost completely, leaving but a few feathers, mostly large pennae. Consumption was calculated as 431 g of poisoned sparrow per kilogram body mass over the full extent of the trial, at a mean daily rate of 3,1% of the body mass. A post-mortem examination indicated that the cat died of internal bleeding, mostly originating from a perforated rectal wall, and forming a large blood-coagulum in the pelvic region and considerable bloody fluid in the abdominal cavity.

Both laboratory rats died, on the eighth and ninth day respectively. They appeared notably less active from the sixth day, with semi-drawn eyelids and blood around their noses on the seventh day. Some fresh specks of blood were observed in the cage from the seventh day, as well as coagulated blood on their tails. A total of 14 poisoned sparrows was given to the rats, of which edible remains in the cage were estimated to constitute one carcase. A lot of feathers and skeletal parts also remained uneaten. It was therefore estimated that 13 sparrows were consumed by the two rats, at a daily rate of 9,5% of their body mass (Table 3). A post-mortem examination of the rat which died first indicated death by excessive internal bleeding, especially from the urogenital system and in the lungs. Exhibiting similar symptoms, it was assumed that the second rat also succumbed to internal bleeding.

Both the steppe buzzard and spotted eagle owl exhibited no signs of secondary poisoning over a treatment period of 18 days. The steppe buzzard was given 61 poisoned sparrows, of which edible remains were estimated as the equivalent of two sparrows. Some feathers also remained. It was therefore estimated that 59 sparrows were consumed, at a mean daily rate of 13,0% of the buzzard's body mass (Table 3).

The feeding behaviour of the spotted eagle owl consisted of removing the remiges and rectrices before swallowing the complete carcase, and regurgitating undigested remains in pellets. Fifty-two sparrows were taken, at a mean daily rate of 9,8% of the owl's body mass (Table 3).

TABLE 3

Secondary poisoning hazards of cumatetralyl-treated Cape sparrows to some carnivorous vertebrates.

	Test subject			
	Domestic cat	2 Laboratory rats	Steppe buzzard	Spotted eagle owl
Body mass of test subject (g)	4 600	198 ; 208	634	742
Number of birds consumed	79	13	59	52
Number of days exposed	14	8 ; 9	18	18
Bird mass consumed per kg(g)*	431	804	2 338	1 760
Bird mass consumed per kg per day(g)*	31	95	130	98
Result of trial	Dead	Dead	Survived	Survived

*Mean body mass of poisoned Cape sparrows taken as 25,12 g.

Both birds of prey were released one day following conclusion of the trials and they flew away without any signs of suffering from secondary poisoning.

DISCUSSION

Using the same product and concentration as for this study Giliomee (1982) found that captive Cape sparrows died within six days when subjected to a food source consisting of only cumatetralyl-treated white bread. These data demonstrated the potential of cumatetralyl as an avicide. However, certain aspects needed further investigation, notably any possible repellent attributes, the toxic efficiency regarding the target species, and the dangers of secondary poisoning to predators; all attended to in this study. Potential hazards of poisoning campaigns to the diverse communities of non-target bird species in grape-producing ares were also studied, using elevated feeding tables, and will be reported elsewhere (Heÿl in press).

Small passerines such as sparrows have a high metabolic rate (Kendeigh, Dol'nik & Gravrilov 1977). If an alternative unpoisoned food source had been absent under captive conditions, this could have resulted in partial or total starvation caused by any repellent attributes of cumatetralyl, and death within a few days. Partial starvation could also have caused a condition of metabolic stress. It was considered possible that only under such circumstances could cumatetralyl operate as an effective avicide. In the primary toxicity trial, apart from providing an alternative food source, natural conditions were further simulated by containing the Cape sparrows in a large aviary, largely isolated from human disturbance, and starting the trial after several days in order to allow the birds to recover from any stress incurred during capture and to adapt to aviary conditions. These more favourable environmental conditions probably resulted in deaths occurring over a longer period than observed by Giliomee (1982). The final result, however, was the same in so far as the sparrows succumbed to poisoning, indicating that cumatetralyl could be a successful avicide under field conditions.

The initial decline in the consumption of bread after poisoning was started, indicates that the sparrows were repelled to some extent by the toxicant. However, the birds continued taking the treated bread, and gradually increased their consumption at the expense of the seed ration. This change in diet probably relates to the ease with which the poisoned birds could consume the wetted bread, as compared to the greater energy required for the opening of seeds.

The estimated LD_{50} of 5,5 x 38,3 mg kg^{-1} for the Cape sparrow is about 140 times higher than the LD_{50} of 5 x 0,3 mg kg^{-1} reported by Hermann & Hombrecher (1962) for the laboratory rat. Low toxicity was also noted for the red-winged blackbird *Agelaius phoeniceus* with a LD_{50} of 23 x 6,73 mg kg^{-1} and the domestic fowl *Gallus* sp. with a $LD_{50} > 8$ x 30 mg kg^{-1} (Anon. 1968). G. Hermann (*in litt.* 1982), following a specific request for information on the use of Racumin as an avicide, subjected the congeneric house sparrow *Passer domesticus* to cumatetralyl-treated drinking water at a concentration of 0,026% active ingredient, as recommended for use against rodents. Two birds died by bleeding in the course of one week, leading Hermann, as an employee of the manufacturing company, to conclude that "Racumin is not an effective avicide and we do not recommend the registration for this purpose." Information therefore indicates that this highly effective rodenticide is not suitable for use against problem birds such as the Cape sparrow, due to the large quantities needed to kill the birds.

Hermann & Hombrecher (1962) stated that the risk of secondary poisoning in the case of the domestic dog *Canis familiaris* was small, for dogs refused to take sick or poisoned rats. In tests by the above authors domestic cats did not sustain secondary poisoning after consuming a number of poisoned rats over a five-day period. Anon. (1968) indicated the subchronic toxicity of cumatetralyl to be substantially higher than its acute toxicity, and the poison is therefore fairly safe against accidental, single exposures. Cumatetralyl, when used according to prescription, is therefore a most effective rodenticide, constituting little danger to other animal species, especially when viewed in terms of the hazards of secondary poisoning.

This study, however, indicates that cumatetralyl, applied at a concentration of 0,053% active ingredient, occurs in sufficient quantities in poisoned Cape sparrows to cause secondary poisoning in some carnivorous vertebrates. In some regions the Cape sparrow tends to breed colonially, and non-breeders are generally gregarious, with feeding flocks numbering hundreds of birds and communal roosting involving up to 100 individuals (Maclean 1985). Poisoning campaigns directed against the superabundant Cape sparrow in grape-producing areas of the south-western Cape (Rowan 1966), together with the gregarious behaviour, could result in large-scale and easily obtainable sources of poisoned food. Predators could soon learn to exploit these sources, probably with decimating effects. The long period over which Cape sparrows died under captive conditions indicates that a reduction in the concentration of the poison to alleviate secondary poisoning hazards would not be feasible under field conditions, where it is likely that the birds would be less exposed to the treatment.

Anticoagulants are not registered as avicides in South Africa. However, circumstantial evidence by G.W. Dyer (*in litt.* 1983) and M.J. Versveld (*in litt.* 1983) indicates the unauthorized use of such poisons in certain grape-producing areas of the south-western Cape, and suggests cases of secondary poisoning.

Food is of primary importance in regulating both nestling production (Dyer, Pinowski & Pinowska 1977) and the numbers of immature and adult granivorous birds (Lack 1966). Rowan (1966), however, indicated a high rate of predation on Cape sparrow eggs and nestlings in the south-western Cape, and it is likely that free-flying populations would also be subject to significant predation. Cape sparrow breeding activity occurs mainly from August to December (Rowan 1966), resulting in an estimated trebling of numbers by the end of the breeding season (Rowan 1973). Populations are therefore at a peak during the austral summer months, a time when food resources, including fruit crops, would probably not be restrictive. Predation by a wide variety of raptors (Maclean 1985), mammalian carnivores (Stuart 1981) and snakes (Broadley 1983) in the south-western Cape could act as a regulatory mechanism, limiting bird numbers during the cropping season, albeit of a temporary nature and additional to annual mortality predominantly caused by other factors. Populations of these carnivorous vertebrates should therefore be protected against the indiscriminate use of poisons, particularly the hazards of secondary poisoning. It is concluded that cumatetralyl is an environmentally undesirable toxicant for controlling the Cape sparrow.

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