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# The Sensitivity of Australian Animals to 1080 Poison VIII.* Amphibians and Reptiles

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*Abstract*

Amphibian and reptile species that have been tested in Australia are generally more tolerant to 1080 poison than are most other animals. The most common signs of poisoning amongst both groups of animals are a lack of movement or convulsions. Visible signs of poisoning first appeared from 13 h to almost 7 days after dosing. Deaths followed from 15 h to almost 22 days after dosing. It is unlikely that amphibians and reptiles face any direct poisoning risk from pest-poisoning campaigns involving 1080, given their high tolerance and the enormous amounts of poisoned bait that would have to be eaten. Some individuals, however, could be detrimentally affected through ingesting sublethal quantities of 1080.

## Introduction

Although amphibians and reptiles are reputedly very tolerant to 1080 poison (sodium fluoroacetate) (Chenoweth 1949), very few data are available to substantiate this. The objective of this study was to determine whether some reptiles and amphibians in Australia might be killed by 1080-poisoning campaigns directed against rabbits *Oryctolagus cuniculus*, dingoes *Canis familiaris* and feral pigs *Sus scrofa*. Although the species tested partly depended upon opportunistic collecting, an effort was made to include representatives of those species most likely to be exposed to poisoning. Sand goannas or Gould's monitors *Varanus gouldii*, lace monitors *V. varius*, shingle-back, bobtail or sleepy lizards *Tiliqua rugosa*, and blotched blue-tongued lizards *T. nigrolutea* have either been observed scavenging, or are likely to scavenge, poisoned meat baits intended for dingoes or pigs; shingle-back lizards, blotched blue-tongued lizards, and bearded dragons *Pogona barbatus* have either been observed eating, or are likely to eat, poisoned carrot bait intended for rabbits.

## Methods

All species were caught by hand in the field. The spotted grass frogs *Limnodynastes tasmaniensis* were kept in a large plastic jar containing leaves and moist tissue paper, and were fed mealworms. The reptiles were kept in either indoor wire cages or outdoor enclosures (Table 1) and fed rotten fruit, canned pet food, boiled eggs, minced steak or young mice, guinea pigs and rabbits. Other details of the experimental conditions are shown in Table 1.

Because of limited numbers of test animals, median lethal doses ($LD_{50}$s) could be determined for only three species of reptiles. Four groups, each consisting of three blotched blue-tongued lizards and two Gould's monitors, were given doses of 1080, the dose each time differing by a factor of 1·26. Groups of

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five shingle-back lizards from South Australia were given doses which increased by a factor of 2·0, and groups of 9–15 shingle-back lizards from Western Australia were given doses which increased by a factor of 1·25 (indoors) or by a factor of 2·0 (outdoors). Only crude toxicity data, representing the range between the lowest doses at which individuals died and the highest doses at which they survived, could be obtained for the spotted grass frogs, bearded dragons and lace monitors because of insufficient numbers of test animals. Both male and female blue-tongued lizards and Gould's monitors were used because of the limited numbers of animals collected. The sex of the animals in the other trials was not ascertained, nor the age of any of the animals used.

**Table 1. Details of experimental conditions for $LD_{50}$ trials on amphibians and reptiles**

| Species | Stock soln used (mg ml$^{-1}$) | *N* | Body weight (g) mean and range | Source |
|---|---|---|---|---|
| Amphibia | | | | |
| Spotted grass frog, *Limnodynastes tasmaniensis* | 7·5 | 7 | 4·6(2–5) | Macquarie Marshes |
| Reptilia | | | | |
| Bearded dragon, *Pogona barbatus* | 10; 100 | 7 | 267 (145–450) | Brindabella Range, N.S.W. |
| Gould's monitor, *Varanus gouldii* | 25; 50 | 8 | 732 (412–1486) | Yunta, S.A. |
| Lace monitor, *V. varius* | 100 | 2 | 3647 (2778–4516) | Macquarie Marshes |
| Blotched blue-tongued lizard, *Tiliqua nigrolutea* | 100 | 12 | 434 (250–638) | Brindabella Range, N.S.W. |
| Shingle-back lizard, *T. rugosa* | 100; 400 | 20 | 468 (280–690) | South Australia |
| *T. rugosa* | 100; 400 | 50 | 351 (160–560) | SW. Western Australia |
| *T. rugosa* | 100; 200; 800 | 49 | 349 (100–610) | SW. Western Australia |

| Species | Housing | Time of dosing (h) | Season | Rectal temp. (°C) | Ambient temp. (°C) |
|---|---|---|---|---|---|
| *L. tasmaniensis* | Jar | 0900–1140 | Spring | — | 12–20 |
| *P. barbatus* | Indoor cage[A] | 0900–1030 | Summer | — (25–40)[B] | 21 |
| *V. gouldii* | Outdoor enclosure | 1139–1415 | Spring-summer | 26–35 (34–36)[B] | 22–29 |
| *V. varius* | Outdoor enclosure | 1225–1445 | Summer | 34·5 (33–37)[B] | 25–29 |
| *T. nigrolutea* | Outdoor enclosure | 1350–1545 | Summer | 30·7–36·3 (26–38)[B] | 16–32 |
| *T. rugosa* (S.A.) | Indoor cage[A] | 1345–1430 | Summer | — | 27–29 |
| *T. rugosa* (W.A.) | Indoor cage[A] | 0930–1030 | Summer | — | 27–29·5 |
| *T. rugosa* (W.A.) | Outdoor enclosure | 1100–1300 | Summer | — | 8–39·5 |

[A] Wire cage in controlled-temperature room.
[B] Field $T_B$ of active animals from Heatwole (1976); data for *T. nigrolutea* from closely related *T. scincoides*.

Frogs were held in the hand and the 1080 administered by intraperitoneal injection. Lizards were also held in the hand or in cloth bags and the 1080 administered orally, with a hypodermic syringe and oesophageal catheter, inserted through a wooden mouthgag. Reptiles kept outside were dosed with 1080 only when their body temperatures (measured with a cloacal thermometer) were within or as close as conditions allowed to the range of body temperatures reported for active individuals in the field (Heatwole 1976).

All 1080 used was AR sodium monofluoroacetate (95·8% purity) dissolved in deionized water, or commercial grade 1080 (92% purity). All $LD_{50}$s and toxicity data obtained by the use of solutions of commercial 1080 have been corrected and expressed as values for AR sodium monofluoroacetate for comparative purposes.

After being dosed, each individual was inspected at least four times per day over the first week and, if then still showing signs of poisoning, twice per day thereafter until it either recovered or died. All observed signs of poisoning and mortalities were recorded and LD$_{50}$s obtained, where possible, by the moving-average method of Thompson (1947) and Weil (1952).

## Results

The intervals between dosing and the onset of signs of poisoning, until death occurred, and LD$_{50}$s or toxicity data for each species are shown in Table 2. Affected animals usually became lethargic or did not move either from basking in the sun to shadier areas or shelter, or *vice versa*. Several *T. rugosa* were observed foaming at the mouth. Other lizards and the frogs were observed lying on their stomachs with outstretched, rapidly twitching legs or toes, or blinking their eyes, trying to regurgitate and breathing very shallowly. A few lizards were also seen lying on their backs paddling their legs in the air, convulsing.

**Table 2. Length of time until signs of poisoning were observed, time until death and LD$_{50}$s for amphibians and reptiles poisoned by 1080**

Values in parentheses represent numbers of animals observed. 95% confidence limits follow the LD$_{50}$s

| Species | Time until signs (h) Median | Time until signs (h) Range | Time until death (h) Median | Time until death (h) Range | LD$_{50}$ (mg kg$^{-1}$) and 95% CL |
|---|---|---|---|---|---|
| Spotted grass frog | 21·8 | 12·9–77·5 (3) | 78·4 | 36·8–98·3 (4) | *c.* 60[A] |
| Bearded dragon | – | 15·2 (1) | 22·8 | 14·9–24·2 (6) | <110[A] |
| Gould's monitor[B] | 47·4 | 24·2–141·2 (5) | 111·6 | 66·5–292·5 (10) | 43·6 (27·5–69·2) |
| Lace monitor[B] | 83·9 | 26·6–141·3 (2) | 109·5 | 73·6–145·4 (2) | <119[A] |
| Blotched blue-tongued lizard[B] | 90·6 | 13·3–160·9 (6) | 130·5 | 14·4–522·5 (13) | 336·4 (232·4–487·1) |
| Shingle-back (S.A.) | – | – | 89·0 | 21–134 (7) | 205·9 (147·2–289·1) |
| Shingle-back (W.A.) | – | – | 174·0 | 22–363 (27) | 507·7 (447·0–577·1) |
| Shingle-back (W.A.)[B] | – | – | 168·0 | 24–432 (23) | 543·2 (500·5–589·5) |

[A]From limited data only. [B]Outdoor trial.

Approximately 82% of all individuals observed to show signs of poisoning died, and 18% recovered. Two Gould's monitors recovered 7·5 and 18 days after being dosed, respectively, and one blue-tongued lizard 17·7 days after being dosed.

## Discussion

### *Signs of Poisoning*

Two characteristic features of 1080 poisoning in frogs and lizards are the long period before signs of poisoning are observed (median times of 22 h and 56 h, respectively) and the long period until death (median times of 78 h and 131 h, respectively).

The inability to move caused by 1080 poisoning may, through disruption of behavioural thermoregulation, in some cases actually hasten the time until death and increase the number of lizards killed.

### *LD$_{50}$s*

Three spotted grass frogs survived doses of 50–60 mg kg$^{-1}$, and four individuals died after receiving doses of 62·5–100 mg kg$^{-1}$. Although an LD$_{50}$ was not obtained, it is possibly about 60 mg $kg^{-1}$, which is similar to the 51 (24–108) mg $kg^{-1}$ (converted to a basis of 95·8% pure 1080) obtained for the American bullfrog, *Rana catesbeiana*, by Tucker and Crabtree (1970). Both values are lower than the $LD_{50}$ estimates of 150 mg $kg^{-1}$ obtained for the non-Australian leopard frog, *Rana pipiens* (Chenoweth 1949), and over 500 mg $kg^{-1}$ obtained for the African clawed toad, *Xenopus laevis* (Quin and Clark 1947).

Inadequate numbers of bearded dragons and lace monitors were dosed for $LD_{50}$s to be calculated. One bearded dragon survived a dose of 50 mg $kg^{-1}$ but six others died after receiving doses of 110–450 mg $kg^{-1}$. Both lace monitors died, after receiving doses of 119 and 150 mg $kg^{-1}$, respectively. Unfortunately, there are no toxicity data available on non-Australian reptiles for comparison.

Both the amphibians and the reptiles that have been tested are generally more tolerant to 1080 than most other animals that have been tested. Possible mechanisms for this tolerance are currently being investigated by us. For example, amphibians and reptiles are more tolerant than all birds except the emu (see McIlroy 1984) and all mammals except the opossum, *Didelphis marsupialis*, of America and some mammals in western Australia (see Oliver *et al.* 1977; King *et al.* 1978; McIlroy 1981, 1982*a*, 1982*b*, 1983*a*, 1983*b*).

According to Chenoweth (1949), frogs are more sensitive to 1080 in the summer than in the winter. This does not appear to be related to ambient temperature, because individuals were not more sensitive to fluoroacetate when kept in water at 32°, but may reflect changes in their hormonal balances influencing or increasing their metabolic demands at that time of the year. There was no significant difference between the $LD_{50}$ values for Western Australian *T. rugosa* tested outdoors or in the animal house (Table 2). Those outdoors had access to shelter which moderated the extremes of ambient temperature.

*Tiliqua rugosa* from Western Australia have very high levels of tolerance to 1080, which are significantly higher than those for conspecifics from South Australia (Table 2). This is similar to the situation previously reported for several species of native mammals (Oliver *et al.* 1977, 1979; King *et al.* 1978). *T. rugosa* is an omnivorous species and is known to feed on flowers, leaves and seeds (Cogger 1975; Satrawaha and Bull 1981), and may have evolved an increased tolerance to fluoroacetate through feeding on toxic species of *Gastrolobium* and *Oxylobium* which are abundant in south-western Australia.

Sublethal doses may be important in the evolution of high tolerance to 1080, as the immobility caused could render reptiles more vulnerable to predation and physiological stress.

### *Relative Susceptibility of Amphibians and Reptiles to 1080*

Comparison of toxicity data show that only the spotted grass frogs are more susceptible to 1080 than rabbits and dingoes, and the frogs, bearded dragons and Gould's monitors more susceptible than feral pigs. [This comparison can be made by first calculating the amounts of 1080 that each frog or reptile would have to ingest to receive an $LD_{50}$ (i.e. multiply body weight from Table 1 by $LD_{50}$ in Table 2) and then comparing these amounts with the respective figures for rabbits (0·3–0·7 mg), dingoes (1·1–2·8 mg) and pigs (20·8–80·0 mg) (data from McIlroy 1983*b*).]

The actual risk each non-target animal faces during a poisoning campaign ultimately depends upon how much bait or other sources of 1080 (e.g. poisoned insects or other animals) they eat and upon the concentration of 1080 in this material. [Data on how much bait the animals eat are not easily obtained but the amounts (in grams) of baits containing commercial 1080 that some of the reptiles would have to eat to receive an $LD_{50}$ can be calculated by first converting the amounts of 1080 for an $LD_{50}$ to a 92% purity basis (multiply by 1·04) and then dividing this figure by the concentration of 1080 in the bait. Typical concentrations used in Australia are 0·33 mg 1080 $g^{-1}$ in carrot baits for rabbits and oat baits for pigs, 0·4 mg $g^{-1}$ in oat baits for rabbits, 0·5 mg $g^{-1}$ in pellet baits for rabbits and pigs, 0·014 mg $g^{-1}$ in meat baits for dingoes, 0·144 mg $g^{-1}$ in meat baits for pigs in Queensland.]

Such data on the amounts of baits required for an $LD_{50}$ indicate that most species tested would need to ingest vast quantities of bait to reach a harmful intake of 1080. Shingle-back and blue-tongued lizards, for example, would have to eat approximately 0·12–1·05 kg of rabbit baits (representing 43–172% of their body weight) and 0·4–2·4 kg of meat baits intended for pigs before they ingested an $LD_{50}$. The four relevant species of reptiles would similarly have to eat 1·3–25 kg of dingo baits for an $LD_{50}$. The bearded dragon requires only 23–156 g of carrot bait for a possible lethal dose, but field observations indicate that although individuals may be attracted to the undyed bait by its colour, they are unlikely to eat such quantities (J. Caughley, personal communication 1983).

Gould's monitors, however, could ingest lethal amounts of meat baits intended for pigs (e.g. 130–470 g of bait, representing 31% of their body weight, contains an $LD_{50}$). In comparison, a very heavy pig (e.g. 130 kg) would need to eat only about 2 kg of meat baits (representing 1·6% of its body weight) for an $LD_{99}$. It would seem prudent, therefore, as well as practicable to lower the concentration of 1080 used in meat baits laid for pigs in Queensland in areas containing Gould's monitors.

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