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The Tolerance of Malleefowl *Leipoa ocellata* to 1080

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The distribution and abundance of Malleefowl *Leipoa ocellata* have both declined considerably throughout Australia since European settlement (Frith 1962; Priddel & Wheeler 1990). Malleefowl were previously distributed over much of the southern mainland of Australia, from the south-west of Western Australia to central New South Wales (Blakers et al. 1984). The main cause of the decline has been attributed to the destruction of habitat through clearing for agriculture and the impact of introduced grazing animals (Frith 1962; Priddel & Wheeler 1990). However, indications of declines have also been noted in areas which were uncleared and ungrazed (Brickhill 1987). The impact of predation on Malleefowl by foxes *Vulpes vulpes* was noted as early as 1916 (North 1917). Subsequent workers have recorded high levels of predation by foxes on eggs (Frith 1962), chicks (Priddel & Wheeler 1994) and adult Malleefowl (Booth 1987). It was stated by Priddel & Wheeler (1994) that 'without effective fox control, further extinction of remaining populations of Malleefowl within the New South Wales wheatbelt appears inevitable.'

The use of 1080 baits to control foxes is increasing greatly in fauna reintroduction and management programs in Australia (Friend 1990; Kinnear et al. 1988; Lundie-Jenkins et al. 1993; Short & Smith 1994). Foxes are very sensitive to 1080 (McIlroy & King 1990), whereas some native fauna in Australia have developed very high tolerances to the toxin (Twigg & King 1991). To determine the suitability of using 1080 baits in fox control operations to enhance the conservation of Malleefowl, the tolerance of Malleefowl to 1080 was determined to assess the potential non-target hazard to these birds.

Materials and methods

Malleefowl from captive breeding programs in New South Wales and South Australia were supplied by the New South Wales National Parks and Wildlife Service and the South Australian National Parks and Wildlife Service. Eggs were collected from nest mounds in Western Australia by the Department of Conservation and Land Management and incubated in our laboratory. Birds were housed in outdoor aviaries and were transferred into indoor cages in an animal house maintained at 23 ± 1°C and 70% humidity 1-2 days before dosing.

Table 1 Response of South Australian Malleefowl dosed with 1080. These birds were not bled.

Dose rate (mg kg^{-1})	Number dosed	Number survived
5	1	1
10	1	1
15	1	1
20	1	1
30	2	2
40	2	2
50	2	2
75	2	2
100	2	2
125	1	0

They were fed on small mixed birdseed and mealworms and provided with water *ad libitum*.

To determine the degree of tolerance to 1080 in this species, small numbers of birds from South Australia were injected intraperitoneally with aqueous solutions of 1080 at increasing doses (Table 1). They were observed for four days and symptoms of 1080 intoxication such as depression, trembling, hyperexcitability, rapid panting or convulsions (McIlroy 1984) were recorded.

The tolerance of Malleefowl to 1080 was determined as an approximate lethal dose (ALD) which is the lowest dose that is lethal to 10% of the animals tested, as described in Calver et al. (1989). The ALD was used as there were insufficient birds tested to determine a precise LD50 (a statistical estimate of the dose that will kill 50% of the animals tested).

Once the ALD of Malleefowl was known groups of birds were injected with doses of 1080 solution and changes in their plasma citrate concentrations were monitored. Elevated levels of tissue and plasma citrate result as a consequence of blocking the Krebs cycle by the ingestion of fluoroacetate (Mead et al. 1979). Blood samples were taken from the brachial vein before dosing and 3, 6, 12 and 24 h later to determine the degree of increase in plasma citrate following dosing and to enable comparison with citrate changes in other species of birds (Twigg & King 1989). Plasma was collected after centrifugation at 3000 g for five minutes and stored at –20°C until it was analysed for citrate content. Plasma citrate was determined by a Mira Clinical Chemistry Unit using a citric cobas acid assay kit (Boehringer Mannheim biochemical analysis food analysis).

The trials were approved by the Animal Experimentation Ethics Committee of the Western Australian Department of Agriculture.

Table 2 Mean changes in plasma citrate levels (µg ml) of malleefowl following dosing with 1080.

Dose level (mg kg^{-1})	Number dosed	Number survived	Background	Changes in citrate level above background 3 hr	6 hr	12 hr	24 hr
NEW SOUTH WALES							
10	4	4	74.8	70.7	—	28.6	—
20	4	4	47.7	—	126.4	60.1	–11.1
50	4	4	79.6	168.6	174.8	92.5	–1.2
100	4	1	74.8	163.2	173.2	109.0	45.6
SOUTH AUSTRALIA							
10	4	4	64.8	44.4	—	18.3	—
20	4	4	57.9	—	90.0	48.4	2.4
50	4	4	49.0	142.7	151.8	103.2	52.8
100	4	2	56.6	191.4	224.8	174.4	65.5
WESTERN AUSTRALIA							
20	2	2	51.7	68.8	79.2	19.5	–21.1*
50	2	2	49.4	170.6	186.1	135.1	52.1
100	2	1	54.5	186.5	246.5	246.5	160.0

* Indicates $n = 1$

Results

All birds from South Australia which were dosed (and not bled) at levels from 5 to 100 mg kg^{-1} survived. The one bird dosed at 125 mg kg^{-1} died (Table 1), while some Malleefowl from all 3 populations died when they were dosed at 100 mg kg^{-1} and bled (Table 2). The Approximate Lethal Dose (ALD) for Malleefowl is thus 100-125 mg kg^{-1}.

The number of Malleefowl dosed and bled, number surviving and changes in plasma citrate levels of Malleefowl from South Australia, New South Wales and Western Australia are shown in Table 2. Doses administered were 10, 20, 50 and 100 mg kg^{-1}.

There were no significant differences between the mean change in citrate elevations above the baseline levels in Malleefowl from Western Australia, South Australia and New South Wales dosed at 100 mg kg^{-1} (Kruskal–Wallis analysis, H = 3.764, *d.f.* = 2). Some Malleefowl from each state died at doses of 100 mg kg^{-1} when the birds had been subjected to the additional stress associated with the bleeding regimen.

Twenty-four hours after dosing the citrate levels of most Malleefowl had returned to near-baseline levels, but the peak levels and the rates at which they declined were highly variable (Fig. 1).

No Malleefowl dosed at 10, 20 or 50 mg kg^{-1} and bled displayed any obvious symptoms of 1080 poisoning, whereas those dosed at 100 and 125 mg kg^{-1} showed symptoms of poisoning after 3-4 hours. Three birds became very still with slow, deep respiration, and were unsteady on their feet approximately 24 hours after dosing and one bird dosed at 100 mg kg^{-1} exhibited muscle spasms and died 29 h after dosing. Symptoms were not observed in the other birds which died overnight between 36 and 48 h after dosing.

Time after dosing to death of Malleefowl dosed at 100 mg kg^{-1} was between 30 and 46 hours (n = 2), 53 hours (n = 1), approximately 72 hours (n = 2) and 12 days (n = 1). Because birds were not observed at night, precise times of death could not always be determined.

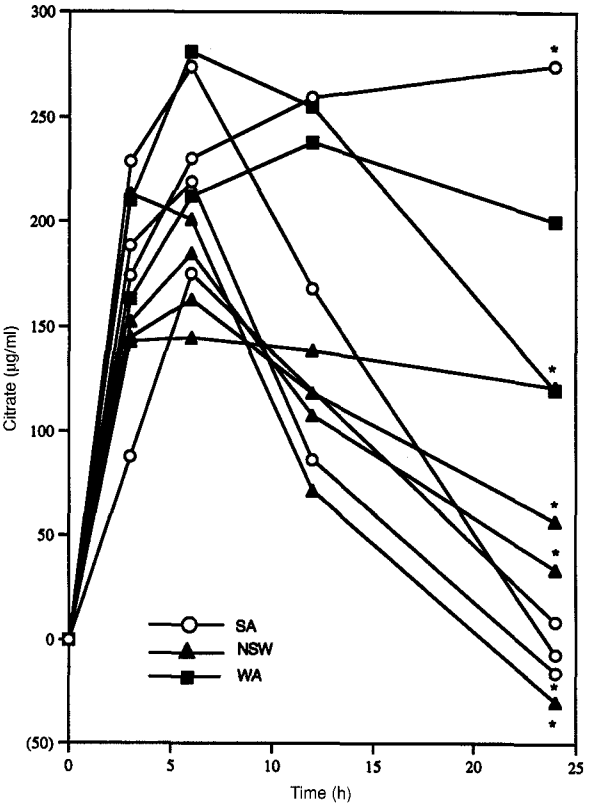

Figure 1 *Changes in citrate levels (µg ml) of Malleefowl dosed at* 100 mg kg^{-1}. * Indicates death. Origin of Malleefowl is indicated.

Discussion

Environmental influences such as contact with humans or other animals can affect an animals' response to drugs (Ellis 1967). The handling and bleeding of animals dosed with 1080 can place additional stress upon them and cause death at doses that animals which had not been handled would survive. The ALD of birds which had been handled and bled several times after they were dosed with 1080 may have been influenced by such stress.

ALDs give similar rankings of the sensitivity of various species to 1080 as do LD50s (Calver et al. 1989) but ALDs give lower absolute (mg kg^{-1}) values than LD50s. ALDs can be more useful in estimating hazards to non-target species, as they indicate the lowest level which is lethal rather than the mean value. Baits can then be designed to be lethal to the target species, while not exceeding the level which could pose an unacceptable risk to non-target species.

Several species of birds native to Australia have been shown to have high tolerances to 1080, apparently because of having co-evolved with fluoroacetate-bearing vegetation (Twigg & King 1989; Twigg et al. 1988). Malleefowl have a very high tolerance to 1080 (ALD = 100 mg kg^{-1}) as do Western Rosellas *Platycercus icterotis* which have an LD50 of approximately 75

mg kg^{-1} (Twigg & King 1989) and Emus *Dromaius novaehollandiae* from Western Australia which have an LD50 of 102 mg kg^{-1} (Twigg et al. 1988). In comparison, most other birds in Western Australia have lower LD50s in the range of 5-40 mg kg^{-1} (Twigg & King 1989).

The similarity of tolerances to 1080 of Malleefowl populations from each location indicates that prior to European settlement and land clearing their almost continuous distribution across Australia (Blakers et al. 1984) enabled gene flow to occur between populations. This gene flow was probably the mechanism by which populations of Malleefowl not in contact with *Gastrolobium* species acquired an elevated tolerance to 1080. Populations of several other bird and mammal species which occupy areas outside of the range of *Gastrolobium* species have also retained higher than expected tolerances to 1080 (Twigg & King 1989; 1991).

As with our study, McIlroy (1984) also found considerable variability in time until death in a range of different birds which he dosed with 1080.

Programs using 1080 baits for controlling foxes on Malleefowl reserves are being implemented in South Australia, New South Wales, Victoria and Western Australia. Rabbit control using 1080 oat baits is conducted on some reserves and national parks to reduce soil erosion and damage to the vegetation. Malleefowl in eastern and western Australia have very high tolerances (100 mg kg^{-1}) to 1080 but both foxes (LD50 0.13 mg kg^{-1} McIlroy & King 1990) and rabbits (LD50 0.35 mg kg^{-1}, McIlroy 1982) are very sensitive to this toxin. This disparity in the tolerances of these species enables 1080 baiting programs to be used successfully to control foxes or rabbits in the presence of Malleefowl while presenting no risk of accidental poisoning to these birds. To ingest 50 mg of 1080, an adult Malleefowl weighing 1 kg would need to eat 17 dried meat fox baits containing 3 mg of 1080, or over 1100 1080-poisoned oats used for rabbit control. As both of these scenarios are highly unlikely, and because most adult Malleefowl weigh significantly more than 1 kg, it is unlikely that any 1080 baiting campaigns would adversely affect Malleefowl populations. This is particularly so given that no Malleefowl in our trials showed any symptoms of poisoning when it had been dosed at 50 mg kg^{-1}.

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Observations on the Endangered Black-breasted Button-quail *Turnix melanogaster* Breeding in the Wild

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The Black-breasted Button-quail *Turnix melanogaster* is an Australian endemic that is difficult to observe in the wild. It is one of 16 species of *Turnix* button-quails belonging to the family Turnicidae of the monotypic order Turniciformes (Sibley & Ahlquist 1990; Christidis & Boles 1994). Of these species, six are Australian endemics, one is found in both Australia and the Malay Archipelago and the remainder occur in Africa, Madagascar and Asia (Sibley & Monroe 1990). Five species are listed as threatened by the IUCN Red List, three of which occur in Australia: Black-breasted Button-quail, Chestnut-backed Button-quail *T. castanota* and Buff-breasted Button-quail *T. olivii* (Collar et al. 1994). The Black-breasted Button-quail is the only turnicid endemic to vine forest in Australia (Ridley 1983; Marchant & Higgins 1993).

The Black-breasted Button-quail is listed in the IUCN Red List as endangered mainly because its total population is thought to contain fewer than 2500 mature individuals and continues to decline in response to severe fragmentation of its habitat such that no single population is thought to exceed 250 mature individuals (Collar et al. 1994). Under Appendix 2 of CITES (1989), the Australian *Endangered Species Protection Act 1992* and the Queensland *Nature Conservation Act (Regulations) 1994*, the Black-breasted Button-quail is listed as vulnerable. In New South Wales under the *Endangered Fauna Act*, it is listed as a Schedule 12 species.

While the breeding biology of the Black-breasted Button-quail in captivity is well studied (e.g. Phipps 1976; Mills 1985; Shephard 1989; Roulston 1992), there is little information on nidification by wild birds. Most information deals with descriptions of clutches (Campbell 1901; North 1913–14; Barnard 1925; Barry & Vernon 1976) and sightings of hatched young (Jerrard 1927; Hughes & Hughes 1991).

This paper describes new information on the courtship behaviour, nesting behaviour and nests of the Black-breasted Button-quail in the wild documented by John Young in south-east Queensland and north-east New South Wales while searching for nests from 1969 to 1979. For this paper, observations are presented on the breeding activity associated with eight nests at five different locations, including one observation in 1985. John Young, a wildlife consultant and naturalist interested in the breeding biology of birds, was interviewed by Anita Smyth about his observations. A summary of that interview is presented in this paper.