Historical accounts of toxicity to introduced carnivores consuming bronzewing pigeons (*Phaps chalcoptera* and *P. elegans*) and other vertebrate fauna in south-west Western Australia

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ABSTRACT

South-west Western Australia is an area with a high number of conservation listed marsupials (Maxwell *et al.* 1996). The presence of *Gastrolobium* (Fabaceae: Mirbelieae) plants, toxic to introduced species because of their production of fluoroacetate, is considered a significant contributory factor to the survival of mammal biodiversity within this region. One benefit attributed to these toxic plants is buffering the predatory impact of introduced carnivores, with native fauna becoming toxic to predators from feeding on the plants. This study supports the existence of this phenomenon and reports accounts from historical literature and from interviews with early rural residents of the region being: Twenty-six historical accounts of the poisoning of domestic cats (*Felis catus*) and dogs (*Canis lupus familiaris*) through consumption of the bones (*n*=11) and/or remains of bronzewing pigeons (*Phaps chalcoptera* and *P. elegans*). A further nineteen accounts were of poisoning arising from the remains of marsupial species such as the brush-tailed possum (*Trichosurus vulpecula*) and boodie (*Bettongia lesueur*) and thirteen accounts of poisoning from remains of *Gastrolobium* poisoned sheep. Where recorded, toxicity is attributed to consumption of *Gastrolobium* plant material by the native species. These accounts are discussed in light of their contribution to the survival of critical weight range native fauna in these habitats. The reports indicate that increased emphasis on the maintenance and restoration of *Gastrolobium* plants and thickets through appropriate fire regimes is likely to aid survival of native fauna through improved shelter, food supply and secondary poisoning of introduced predators. Further research is warranted to confirm toxicity of native animals to introduced predators in remnant *Gastrolobium* habitat, and to monitor introduced predator survival.

Key words: bronzewing pigeon, *Phaps chalcoptera, Phaps elegans, Trichosurus vulpecula, Gastrolobium, Bettongia,* marsupial, possum, fluoroacetate, chemical defence, conservation

Introduction

The toxicity of *Gastrolobium* (Fabaceae: Mirbelieae) due to its production of fluoroacetate is well recognised (eg. Twigg *et al.* 1996), as is the comparatively high fluoroacetate tolerance of Australian fauna exposed to this toxicant (through consumption of *Gastrolobium* plants or animals which had fed on these plants; King *et al.* 1978). The potential secondary poisoning risk to predators of fluoroacetate poisoned animals is similarly recognised (Casper *et al.* 1986; Algar and Kinnear 1996; Heyward and Norbury 1999; Murphy *et al.* 1999). Although many native animals feed extensively on *Gastrolobium* (eg. Serventy and Whittell 1976; Twigg *et al.* 1983; Mead *et al.* 1985; Twigg 1986; Twigg 1994; Shepherd *et al.* 1997; Johnstone and Storr 1998) there has been only little consideration of the potential for those native animals to become toxic themselves, excepting bronzewing pigeons (*P. chalcoptera* and *P. elegans* - Whittell 1938; 1942; Erickson 1969; Serventy and Whittell 1976; Dumbacher and Pruett-Jones 1996; Higgins and Davies 1996). There have been suggestions that native vertebrate species feeding on *Gastrolobium* may have been toxic to predating foxes and cats and that this toxicity has aided the survival of small mammal fauna in south-west Western Australia (Christensen 1978; Anon. 1980; Christensen 1980b; Hopper 1991).

Native mammals of between 35-5500g (often referred to as the critical weight range, CWR) have suffered much higher extinction rates and reductions in range than other mammals in Australia (Burbidge and McKenzie 1989; Cardillo *et al.* 2006; Johnson *et al.* 2007; McKenzie *et al.* 2007; Johnson and Isaac 2009). However in south-west Western Australia species such as the woylie (*Bettongia penicillata*), numbat (*Myrmecobius fasciatus*) and chuditch (*Dasyurus geoffroii*) have persisted, and species such as the bilby (*Macrotis lagotis*), last collected in 1935, and the boodie (*Bettongia lesueur*), last collected in 1942, (Abbott 2001) become extinct only relatively recently compared with their loss many decades ago from other areas of their historical range (Strahan 1995). Shortridge (1910) notes that some of these south-west Western Australia species suffered declines early in the period of influence by Europeans and their plants and animals. A suggested cause of the early declines in CWR fauna is disease, with Abbott (2006) proposing an epizootic between about 1875 and 1925 caused significant declines in some species. In their recovery from these early declines, CWR fauna had to deal with numerous European-associated impacts, which included predation by the feral cat (*Felis catus*) and red fox (*Vulpes vulpes*). Following its release in Victoria in the 1860s (Rolls 1969), the fox was not reported in the Western Australian wheat belt until 1919 (Anon. 1919). With high rabbit (*Oryctolagus cuniculus*) numbers the fox population built up rapidly such that it was soon considered a major pastoral concern (eg. Long 1988). Christensen (1978), in a report to the (then) Wild Life Authority of Western Australia, presented compelling circumstantial evidence that fox predation was the primary cause for the decline, in some cases to extinction, of 'the medium sized native mammal species' in the south-west of Western Australia. This has been supported by the later studies of Friend (1990) and Kinnear *et al.* (2002).

Notwithstanding the benefit of the comparatively late arrival of the fox to the south-west, the presence of toxic *Gastrolobium* plants has been suggested as a significant contributory factor to survival of CWR mammals within the region (Calaby 1971; Christensen 1978; Anon. 1980; Christensen 1980b; Hopper 1991). The presence of these plants is considered to have historically provided, and possibly still provide, at least four significant benefits to aid the survival of CWR fauna. Firstly it provides a refuge due to the dense thickets some species produce (Christensen 1980a; Short 2004). Secondly, because of the toxic impact upon pastoral animals, presence of *Gastrolobium* tended to inhibit and deter vegetation clearance for pastoral development (Anon. 1911b; Calaby 1971). Thirdly, these plants provide an excellent food source (eg. Shepherd *et al.* 1997). Finally, native vertebrates that consume the seed and vegetative material of *Gastrolobium* may become toxic to predators, and this toxicity may have provided some buffering of the impact of introduced predators on native fauna (Calaby 1971; Christensen 1978; Anon. 1980; Christensen 1980b; Hopper 1991).

Evidence to support the hypothesis that native animals poisoned predators after consuming *Gastrolobium* has to date been lacking in the scientific literature. Therefore a literature search was made to locate historical reports of this phenomenon in newspapers and other media from the period 1885 to 1965, with the primary source considered being an editorial column in 'The Western Mail' newspaper. In addition, interviews were conducted with people who may have experienced or heard of native animals being poisonous to dogs or cats. Numerous accounts of toxicity, primarily attributed to the bones of bronzewing pigeons (*P. chalcoptera* and *P. elegans*) and the remains of native marsupial species and *Gastrolobium* poisoned sheep, were located. Reports obtained from the literature search and interviews are presented with discussion regarding likely ecological implications, especially for the survival of CWR fauna species in this region.

Methods

The primary search criteria were for Western Australian articles discussing the deaths of animals from eating:

1. native fauna;
2. *Gastrolobium*; or
3. *Gastrolobium* poisoned stock.

These accounts were sourced by reviewing issues of Western Australian newspapers, and assorted natural history and rural history publications. Published accounts that mentioned stock poisoning from other poisonous plants, generally associated with plant samples submitted for identification, were excluded, as were reports of dog deaths attributed to strychnine.

The main source of accounts outlining toxicity in native vertebrates of south-west Western Australia was a column in 'The Western Mail' newspaper, an agricultural newspaper that circulated throughout Western Australia from 1885 to 1955, then became 'Countryman', a currently published newspaper. The column was entitled 'Our Mutual Help', 'Mutual Help' or similar and was begun by the agricultural agronomist and journalist Mr William Catton Grasby (b. 1859; see http://www.adb.online.anu.edu.au/biogs/A090083b.htm) on 3rd February 1906. The Battye Library in Perth, Western Australia, possesses a file of the correspondence between Mr Grasby and rural residents of that period (call number MN 139), along with microfilms of 'The Western Mail'. The volumes of 'The Western Mail' and other newspapers searched are listed in Table 1, with the Western Mail primarily searched, issue-by-issue, from the commencement of the 'Our Mutual Help' column until the issue of January 4, 1940 when searching was halted. Photocopies of most written accounts are held by D.E.P.

In addition, Dr Ian Abbott (Science Division, DEC, Perth) provided a list of early residents of rural south-west Western Australia and where possible these people were interviewed about their knowledge of toxic wildlife (Appendix B).

In the analysis of results, where obvious, duplicate or linked accounts from the same author were counted as one observation.

Results

Forty accounts (plus one ambiguous) were located that discussed the toxicity of native fauna, with all but one of these being from south-west Western Australia. Of these, 28 accounts discuss the toxicity of the common and brush bronzewing pigeon, with 14 accounts specifically mentioning the source of toxicity as the bones of these pigeons. One of these accounts states *P. elegans* to have been 'known by a number of our old settlers as the "poison pigeon"' (Anon. 1917b p. 4). Ten accounts (plus one ambiguous) report cats or dogs dying from 'opossum' (most likely *Trichosurus vulpecula*) remains, eight from remains of kangaroo or wallaby, and five (plus one ambiguous) from the remains of 'boodie' (*Bettongia lesueur*), 'kangaroo rat' (*B. penicillata*) or 'the entrails of a rat or wallaby'. A further 16 (plus one ambiguous) accounts report dogs dying from

Table 1. Newspapers searched for reports of vertebrate toxicity

Newspaper	Searched		Microfilm Reel Number
	From	To	
The Western Mail	19.12.1885*	30.1.1886	1
The Western Mail	11.2.1905	4.1.1940	64-208
The Albany Advertiser	20.2.1897*	1.4.1897	1
The Albany Mail & King George's Sound Advertiser	1.1.1883*	21.8.1883	1
The West Australian	13.1.1897	15.1.1897	47
The West Australian	2.4.1906	2.4.1906	117
The Great Southern Herald	5.10.1901*	16.11.1901	1

* First issue

eating the remains of *Gastrolobium* poisoned sheep or goats, with another account believing this to have arisen from the dog eating a rabbit poisoned from feeding on narrow-leaved poison (*G. stenophyllum*?).

Accounts disputing the toxicity of species include two 'opossum' accounts (Anon. 1907e; Bert 1907 - though Anon. 1907e had known dogs die from 'kangaroo rat' entrails), one kangaroo account (Anon. 1921a) and one account of tammar wallaby (*Macropus eugenii*) entrails (Anon. 1921b - though they were yearly losing cats from eating bronzewing pigeons).

This account summary, and its sources, are presented in Table 2, with accounts detailed in the attached appendices. Of the 49 written and oral account sources that detail animal toxicity (often multiple accounts), 40 (82%) detail accounts from native fauna and 17 (35%) detail accounts from sheep, goats or a rabbit. In addition, 25 sources (51%) state accounts detailing a bone or tissue retained toxicant while 31 (63%) state accounts that either fail to state a toxicant source, state poisoning from ingestion of gastro-intestinal material, or the toxicant source is ambiguous.

In almost all cases where the source of the toxicant was detailed (n=32) it was attributed to the animal having fed on the seeds, leaves or flowers of *Gastrolobium* plants. Mention of 'poisonous berries' by Anon. (1912c; d) could be a misrepresentation of poisonous *Gastrolobium* pods and/or seeds, or suggestive of an alternative, fruiting, toxicant source. As Johnstone and Storr (1998) only found seed, with *Gastrolobium* seed listed, to be eaten by *P. chalcoptera* and *P. elegans*, mention by Anon. (1912d) that bronzewings feed on 'poisonous berries' in summer, suggests misrepresentation of poisonous *Gastrolobium* seed.

In some cases where table scraps/cooked bones are mentioned (eg. Anon. 1912b), it is possible that cats or dogs recorded as showing symptoms soon after feeding on bones were earlier given guts when the animals were cleaned, or muscle tissue. However some detailed accounts seem to preclude that possibility. Webb (1885) specifically mentions *G. bilobum* seed the pigeons feed on as being toxic and hence the behaviour of throwing the pigeon's bones into the fire 'except the breastbone which the dog managed to get', suggesting the author wouldn't have allowed the dog to feed on the guts. The account of Anon. (1917b) specifically states that 'knowing the danger attributed to them in poisoning domestic pets, I removed feathers, crop and insides before taking them home … the bones were thrown out as is usual, and before night my only dog was dead.' He also earlier states 'I have times and times heard of someone losing a dog or cat from eating pigeon bones, but I never could believe it. I always believed that death resulted from eating the contents of the crop or intestines, but I will give you ... my experience and so try to make it more clear where the poison is.' For an account such as this we would argue that no pre-feeding on guts was involved.

Many accounts referred to poisonings occurring when cats and dogs were fed on the discarded tissues, including bones, of native animals that had been cooked and eaten by rural residents. (See *The Western Mail* from April 7 - May 12, 1938 for bush recipes including 'XXXII. Bronzewing Pigeon' on April 21st p. 32 and 'XLVI. Wild Bird Stew or Pie' on May 5th p. 31, which stated 'four plovers, or pigeons, or six parrots (skinned)'). However, some cat death accounts were the result of predation of native species. For example, one account reports their inability to keep a cat permanently due to their cats dying each year from eating bronzewing pigeons in late summer, when the seeds of the poison plants were ripe (Anon. 1921b). *Gastrolobium* most commonly seed in summer to early autumn (K. Smith, Boddington Native Seeds, pers. comm. 2006), and of 20 reports that include information on seasonal timing only one doesn't directly identify this season or mention the birds feeding on seed. The anomalous account states 'I have just had …' and was published in winter (Webb 1885). It is considered that 15g of seed (5g in the crop and 10g in the gastro-intestinal tract) would be the maximum amount in a bronzewing pigeon (Ron Johnstone, Curator of Birds, Western Australian Museum, pers. comm. 2001). As 4mg fluoroacetate would well exceed the LD_{100} for the dog, fox and cat (McIlroy 1981; McIlroy and King 1990; Eason *et al.* 1992), only 1.3-2.6g *G. bilobum*, *G. calycinum* or *G. parviflorum* seed at their mean (derived) fluoroacetate concentrations (Peacock *et al.* 2007) would be required to kill these introduced predators.

By contrast, possum toxicity was most commonly reported in spring (Anon. 1907a; b; c; Clinch 1907; Anon. 1922b) when *Gastrolobium* flowers and possums commonly feed on the flowers (Anon. 1907c; Wansbrough 1922; P. Christensen and J. Foulkes, pers. obs.).

Table 2. Accounts of toxic native animals and related issues, primarily from south-west Western Australia

Toxicity Related Account	**Source***
Bronzewing pigeons killing cats or dogs	9-14, 16-18, 29, 35-38, 40-43, 47- 53, 55, 59, 61
Bronzewing pigeon bones specifically killing cats or dogs	11-14, 29, 36, 37, 43, 48, 49, 52, 53, 55, 59
Cats or dogs dying after eating remains of 'opossum'	4-7, 18, 27?, 33, 38, 45, 48, 59
Cats or dogs dying after eating remains of kangaroo or wallaby	17, 18, 20, 34, 36, 38, 46, 53
Cats or dogs dying after eating remains of 'boodie', 'kangaroo rat' or 'rat'	8, 13, 27?, 36, 38, 46
Pigs dying from eating dead woylies	32
Parrot (esp. *Platycercus zonarius*) or malleefowl (*Leipoa ocellata*) bones considered poisonous	11, 57, 59, 61
Dogs dying after eating remains of *Gastrolobium* poisoned sheep, goat (*n*=3) or rabbit (*n*=1)	1?, 2, 19, 21-23, 25, 26, 28, 31, 33-35, 37, 38, 45-47
Bronzewing pigeons eating *Gastrolobium* seed	9, 13, 16, 18, 29, 35, 36, 38, 39, 41-43, 47-49, 53, 54, 58-61
Quail eating *Gastrolobium* seed	53, 54
Emu (*Dromaius novaehollandiae*) eating *Gastrolobium* seed	30
Possums feeding on *Gastrolobium* seed or plants	4, 6, 18, 33, 44, 45, 47?, 48, 54, 56, 59
Tammar wallaby eating *Gastrolobium* leaves	16, 44, 54
'Boodie' burying *G. calycinum* seed or digging at roots	3, 9
Accounts disputing the 'opossum' (*n*=2), 'kangaroo' (*n*=1) or tammar wallaby (*n*=1) being reported as poisonous	8, 15, 16, 24

* 1 = Anon. (1833), 2 = Anon. (1841), 3 = Anon. (1906), 4 = Anon. (1907a), 5 = Anon. (1907b), 6 = Anon. (1907c), 7 = Anon. (1907d), 8 = Anon. (1907e), 9 = Anon. (1911b), 10 = Anon. (1912a), 11 = Anon. (1912b), 12 = Anon. (1912c), 13 = Anon. (1917a), 14 = Anon. (1917b), 15 = Anon. (1921a), 16 = Anon. (1921b), 17 = Anon. (1922a), 18 = Anon. (1922b), 19 = Anon. (1922c), 20 = Anon. (1922d), 21 = Anon. (1930), 22 = Anon. (1933), 23 = Anon. (1934), 24 = Bert (1907), 25 = Brockman (1834), 26 = Brown (1910), 27 = Cairns (1909), 28 = Cameron (2006), 29 = Campbell (1890), 30 = Chewings (1930), 31 = Chitty (2004), 32 = Christensen (1978), 33 = Clinch (1907), 34 = Coff and Parker (1922), 35 = Drummond (1840), 36 = Editor (1921), 37 = Erickson (1969), 38 = Greig (1907), 39 = Johnstone and Storr (1998), 40 = Knight (1912), 41 = Le Souëf (1900), 42 = Mann (1906), 43 = Serventy and Whittell (1976), 44 = Shepherd *et. al.* (1997), 45 = Spencer (1966), 46 = Stow (1981), 47 = Walter (1847), 48 = Wansbrough (1922), 49 = Webb (1885); 50 = F. Boose pers. comm., 51 = B. de Burgh pers. comm., 52 = W. H. Butler pers. comm., 53 = W. Chitty pers. comm., 54 = P. Christensen pers. obs., 55 = R. Erickson pers. comm., 56 = J. Foulkes pers. comm., 57 = G. McNeil pers. comm., 58 = A. Muir pers. comm., 59 = K. Smith pers. comm., 60 = L. Twigg pers. comm. and 61 = G. Warren pers. comm.

Although the Battye Library in Perth possesses numerous diaries and correspondence of W. C. Grasby, none of the original correspondence he received regarding *Gastrolobium* toxicity exists in this collection. Nor is the correspondence in the archives of 'The West Australian' newspaper, which owned 'The Western Mail', or held in the possessions of the late Ms N. Grasby (John Grasby pers. comm. 2004). Microfilms of 'The Western Mail' do however include many published letters discussing the authors' accounts of primary poisonings from stock consuming *Gastrolobium*, and secondary poisonings from companion animals eating wildlife.

From 1906-1922, the 'Our Mutual Help' column in 'The Western Mail' published 27 letters describing largely first hand observations of *Gastrolobium* and/or wildlife toxicity. Their description is included in Appendix A. The 1923-1940 period of this weekly newspaper contains accounts of stock poisoning, with numerous samples of toxic *Gastrolobium* plants being submitted for identification, but with no additional reference made to toxic native wildlife. By this time species such as the boodie were very rare, and most no longer a primary food source for the rural residents and their pets, or of agricultural concern. Also, on the fertile soils (grassy *Eucalyptus loxophleba* woodland) much of the *Gastrolobium* vegetation had by then been cleared, and where it remained (eg. low fertility farmland such as the kwongan sandplains) its toxicity to livestock was well recognised and procedures for its eradication well understood and documented (Herbert 1921; Carne *et al.* 1926; Dell and Gardner 1937).

Interviews conducted with early residents of agricultural locations in south-west Western Australia revealed a number of accounts of native fauna being poisonous. These accounts are presented in Appendix B. The account from naturalist Dr W. H. (Harry) Butler CBE provided one of the most recent accounts (1965), referring to the death of a young dog after consuming the bones of a common bronzewing pigeon at Dryandra in south-west Western Australia.

Only three of the accounts are outside of the core zone of endemism for *Gastrolobium* in Western Australia (Figure 1), but in all of these cases *Gastrolobium* are present in the vicinity. Anon. (1912b) describes poisoning a cat with the bones of bronzewing pigeons and parrots, and also a dog with bronzewing pigeon bones, during four years of residency in Broome. *Gastrolobium grandiflorum* (180ppm fluoroacetate - McEwan 1964) has been recorded from near Broome (Chandler *et al.* 2002). Mr F. C. Clinch of Burnerbinma Station, via Yalgoo, reports 'opossums' feeding on *Gastrolobium* to be poisonous to dogs (Clinch 1907). *Gastrolobium laytonii* (500ppm fluoroacetate - Aplin 1971) has been recorded from Burnerbinma Station (Patrick 2002). Finally, W. H. Butler stated that the Wongi Aboriginals at Warburton and Cundeelee (Figure 2) advised him to be careful of bronzewing pigeons. This knowledge may have been gained from elsewhere, however *G. grandiflorum* has been recorded from near Warburton (Chandler *et al.* 2002), with *G. aculeatum* (fluoroacetate presence unknown) and *G. spinosum* (0-400ppm fluoroacetate - Aplin 1971) recorded near Cundeelee (Herbarium 2007). Aboriginal knowledge of *G. grandiflorum* toxicity is reported by Charles Chewings, who, in 1906, found that the aboriginal people near Barrow Creek, NT 'knew the deadly nature of the plant [*G. grandiflorum*] so well. They will not camp under the bushes, and say that if they did harm would come to them' (Chewings 1930 p. 321).

The nearest modern location to those mentioned in the written and verbal accounts are shown in Figure 2.

Discussion

The phenomenon of vertebrate species becoming toxic through retention of a dietary toxicant is well recognised in the scientific literature (eg. Aparicio *et al.* 1999; Saporito *et al.* 2004). One example is the South American poison-dart frog (*Phyllobates terribilis*), which possesses the extremely toxic batrachotoxin alkaloid and is considered to be the world's most toxic land vertebrate (Daly 1995). Examples of toxic birds also exist, with New Guinea birds of the genera *Pitohui* and *Ifrita* recently shown to also possess the batrachotoxin alkaloid (Dumbacher *et al.* 1992). In both these examples the toxicant is believed to be from an arthropod dietary source (Dumbacher *et al.* 2004), the species retaining the toxicant without harm to themselves by sequestering it in skin and/or feathers.

The Australian native fauna highlighted in Table 1 (excluding quail – no data) have been found to have significant fluoroacetate tolerance, believed primarily from evolutionary dietary exposure to *Gastrolobium*-sourced

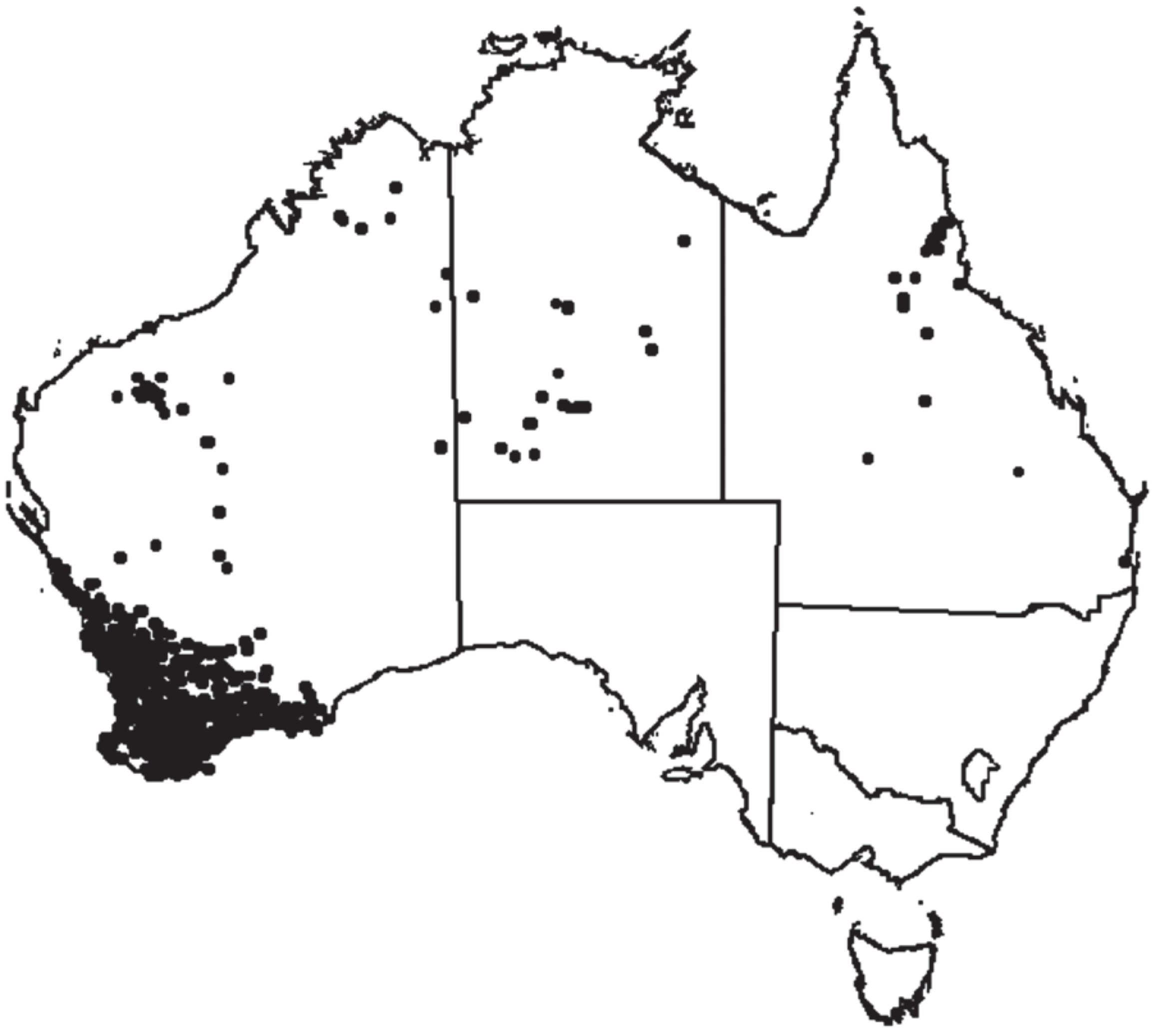

Figure 1. The recorded distribution of *Gastrolobium* (from Chandler, 2002).

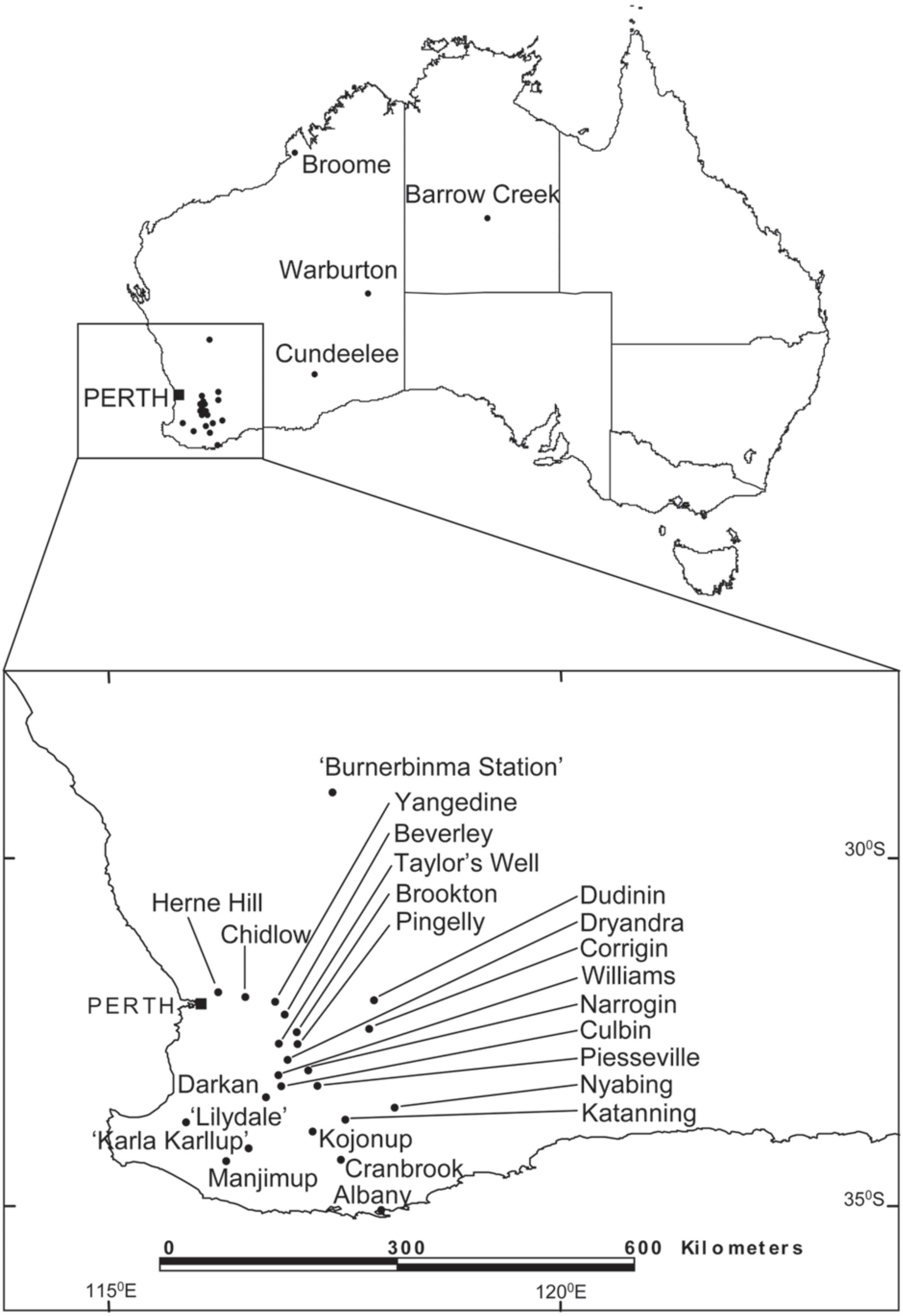

Figure 2. Locations of accounts discussing toxic native animals, Western Australia

(Unless stated otherwise, location of author is assumed to represent the location of the anecdotal account. Latitude and longitude of nearest identifiable feature used. Obtained from Geoscience Australia website (http://www.ga.gov.au/map/names) or W. A. Dept. of Land Administration.)

fluoroacetate (King *et al.* 1978; 1981; Twigg *et al.* 1988; Twigg and King 1989; King *et al.* 1996). The accounts presented in this paper indicate a number of these native vertebrates, which feed on *Gastrolobium* plants and/or seed, may also exhibit toxicant retention. The accounts are sufficiently detailed to indicate retention of toxicant in bones and not merely toxicity of soft tissues in animals that may have fed on *Gastrolobium* shortly before their death.

Historical accounts do not equate to rigorous scientific data but may still be essential to informed management (Swetnam *et al.* 1999; Abbott 2006). In Australia they have been critical to establishing a number of important ecological phenomena that predate mainstream scientific literature; eg. the origin of the feral cat in Australia (Abbott 2002), the hypothesis of epizootic disease as an agent for mammal decline in Western Australia in the period 1875-1925 (Abbott 2006), and the distribution and severity of mouse plagues in the 1900s (Mutze 1989). The strengths and weaknesses in these data are recognised and have been discussed by others (see Davidson and Lytle 1986 p. vi-vii; Robertson *et al.* 2000; Abbott 2006; Abbott 2008 p. 137-139), with a pertinent summary being; 'In historical ecology / ecological history, explanations should be treated as hypotheses with varying degrees of convincingness, dependent on the array of factual and observational evidence available and the quality of the inferences drawn' (Abbott 2008 p. 138).

Although the vagaries of human recollection may erode the accuracy of individual reports, taken collectively (see Abbott 2008 p. 6) the accounts located in this study indicate that poisonings arising from the consumption of native wildlife, particularly from bronzewing pigeons with toxic bones, appear to have occurred commonly in the core zone of endemism for *Gastrolobium* in Western Australia (Figure 1) and that the source of this toxicity was commonly believed to be from consumption of *Gastrolobium* plants or seeds. This toxicant retention is reportedly of sufficient concentration and longevity for species such as *P. chalcoptera* to subsequently become toxic to susceptible predating and scavenging species. We believe that the historical accounts were reporting a real phenomenon that has not yet been well studied scientifically, particularly in relation to rapid deaths and toxic bones. This parallels the scenario of *Pitohui* birds of New Guinea being anecdotally known by locals as 'rubbish birds', and subsequently being shown to contain the toxic batrachotoxin alkaloids (Dumbacher *et al.* 1992).

The earliest account we found to describe native vertebrate toxicity was that of Drummond (1840 p. 2) who reported many believe bronzewing pigeons to feed on the seeds of the unidentified leguminous shrub from a grove at King George's Sound 'with impunity, but dogs that happen to eat the stomachs and guts of the pigeons, die with the same symptoms [undescribed] with those that die from eating poisoned sheep and goats'. Other related sources indicate that the shrub from this grove was probably *G. bilobum* and that the pigeons' feed on the seeds of those shrubs (Francis 1861; Webb 1885; Campbell 1890). The most recent report of vertebrate toxicity was that of naturalist Harry Butler, from Dryandra Forest in March 1965. Although other more recent publications may discuss, or state, toxicity in *P. chalcoptera* and *P. elegans* (Serventy and Whittell 1976; Dumbacher and Pruett-Jones 1996; Higgins and Davies 1996), the lack of recent incidents can be explained by the greatly reduced availability of the toxicant food source. Extensive clearance of *Gastrolobium* (eg. Anon. 1911b) has occurred progressively since its identification as the cause of stock deaths in 1841 (Erickson 1969), with the distribution and abundance of *Gastrolobium* now greatly reduced (Chandler *et al.* 2002). Examples of previous abundance include: Keith Smith stated he used to have a 600m wide patch of *G. bilobum* on his property 'Karla Karllup' (see Appendix B); 'A piece of 80 ac. was the worst piece of poison they had. It was fenced off …' (Anon. 1911b p. E5); 'it was estimated there were 1,300,000 acres of unsettled poison infested land within the boundaries of the area mentioned' (Anon. 1911a p. 7). Also, there has been a corresponding decline in abundance of potentially toxic prey species such as bronzewing pigeons (Le Souëf 1900; Orton and Sandland 1913; Anon. 1921b; Johnstone and Storr 1998) through factors such as hunting and habitat loss. *Phaps chalcoptera* is stated to have been observed in their thousands by Lieut. H. W. Bunbury 'in the summer of 1836' (Serventy and Whittell 1976 p. 262). Legislative protection of bronzewing pigeons and associated fauna began in 1874 with the Game Act. With the lack of modern reliance on wild game as a food source for people and their companion animals, these factors have effectively removed the provision of potentially toxic food to cats and dogs, as historically recorded.

The deaths of cats and dogs, valued for company, hunting, protection and stock management, was of major concern to early European settlers, in addition to the loss of livestock poisoned by consuming *Gastrolobium* plants (eg. Brown 1910; Anon. 1911b). The main native vertebrate species reported to be toxic were the bronzewing pigeon (*Phaps chalcoptera* and *P. elegans*), boodie (*Bettongia lesueur*), 'opossum' (an opossum drawing in a co-published advertisement indicates that these were probably mostly *Trichosurus vulpecula*) and 'kangaroo rat' (woylie; *Bettongia penicillata*). These species were often a primary food source for the settlers, with some also a source of agricultural conflict due to their impact on crops. In most cases the animals were shot or trapped, cooked and eaten, with the remains given to the companion cat or dog. A few correspondents specifically disagreed with the accounts proposing that some native fauna were toxic (eg. Bert 1907; Anon. 1921a). Disbelieving correspondents may have been less likely to report their 'normal' non-toxic experiences, suggesting such 'normal' accounts as these are under sampled. However, concern that the founding colony would be disparaged and prospective colonists scared away (Erickson 1969), land values adversely affected (Anon. 1911b) and perhaps concern about being disparaged for suggesting species, normally perceived as benign and of food value, could be poisonous, likely caused under-reporting of toxic accounts. A likely explanation of the disparity between experiences is that not all of the native animals were, or remained, toxic due to whether or not they had fed on *Gastrolobium*, as well as the demonstrated spatial and temporal variation in concentrations of toxicants in

Gastrolobium (Aplin 1971; Twigg *et al.* 1996; Peacock *et al.* 2007). The letter by Greig (1907, p. 11) supports this explanation when he writes: 'I have known dogs to be fed on opossums not cleaned for weeks without getting poisoned, but eventually they get a poisoned one.' Similarly, Anon. (1907c p. 6) states: 'My opinion is that the opossums caught in country with no poison plant on it will not poison a dog, and … they will not poison a dog if the poison plant is not in bloom or seed.'

Unlike the numerous dog and cat accounts, only one account was located of what was suspected to have been the death of a fox from ingesting a toxic prey species. This was the observation of a dead fox in *G. bilobum* habitat, which, although there was no poison baiting being conducted, appeared to have been poisoned (Christensen 1978). Partly as a result of this observation arose the original suggestion that native mammals feeding on *Gastrolobium* plants may be secondarily poisoning predating foxes (Christensen 1978). This is likely given that dog and cats, with similar sensitivities to fluoroacetate as the fox, were reported to have been dying after feeding on the native wildlife, as well as published accounts of secondary poisoning after 1080 (fluoroacetate) baiting programs (eg. McIlroy and Gifford 1992; Algar and Kinnear 1996; Gillies and Pierce 1999; Murphy *et al.* 1999). Lack of fox accounts is likely due to their being wild (dog and cat accounts are from companion animals), and their establishment in Western Australia in the 1920s, at a time of greatly reduced reliance on native fauna, and greatly reduced *Gastrolobium* distribution and abundance. Hence the period 1923-1940 also provided no toxic native fauna accounts.

Fluoroacetate as the explanatory toxicant

Many of the historical accounts (eg. Greig 1907; Wansbrough 1922; Spencer 1966) could be explained by the now established presence of fluoroacetate in *Gastrolobium* plant material (eg. Aplin 1971; Twigg *et al.* 1996). However the accounts of rapid cat and dog deaths (Webb 1885; Le Souëf 1900; Knight 1912) appear to be below the minimum time threshold for the fluoroacetate 'lethal synthesis' process (Peters 1963; Peters and Shorthouse 1971). This is stated to be 'seldom < 1 hour and 30 min' (Rammell and Fleming 1978 p. 17) and 'seldom less than two hours, even after 10 to 20 times the lethal dose was given' (Quin and Clark 1947 p. 78). Even dosing with the toxic metabolite (-)-*erythro*-fluorocitrate (Kirsten *et al.* 1978) doesn't cause a more rapid death (Bosakowski and Levin 1986). Although fluorocitric acid was reported from 'fluorosed' cattle bones (Peters *et al.* 1969 p. 9), it isn't as toxic as fluoroacetate (Dietrich and Shapiro 1956; Peters and Shorthouse 1971), probably due to the molecule's larger size and hence reduced tissue absorption (Savarie 1984). Conversely, fluoroacetate has been reported to be enzymatically defluorinated (Gal *et al.* 1961; Tecle and Casida 1989) and rapidly excreted (Sykes *et al.* 1987). In *P. chalcoptera,* plasma citrate was still significantly elevated up to at least 8 hours post dosing with a single injected fluoroacetate dose (Twigg and King 1989; Peacock 2003). Hence regular feeding and digestion of *Gastrolobium* seed could enable maintenance, or elevation, of significant temporal tissue/bone fluoroacetate levels. There is some evidence for fluoroacetate being retained in rat (Gal *et al.* 1961) and *P. chalcoptera* (Peacock 2003) bones.

Also, other unidentified toxicants might be involved. Alkaloids have been described from *Gastrolobium* leaves (Mann 1905; 1906; Webb 1949; Cannon and Williams 1982) and the alkaloids colchicine (Panariti 1996) and caffeine (McIntyre *et al.* 2000) found in bone, however analysis of *Gastrolobium* seed has been unable to identify the presence of any alkaloids (Peacock *et al.* 2004). Similarly, other fluoroacetylated compounds might explain the rapid death and bone toxicity accounts. Fluoroacetylated sugars were hypothesised by Hall (1972) and tentatively detected by Peacock (2003). If present, perhaps they are adsorbed and metabolised more rapidly than fluoroacetate, inhibit glycolysis (Taylor 1972) and bind to the hyaluronic acid in bone as per *N*-fluoroacetylglucosamine (Kent and Winterbourne 1977)? It may be that the rapid death accounts are due to a synergism between secondary metabolites (Vining 1990) within the *Gastrolobium* seed, as suggested for the fluoroacetate containing *Palicourea marcgravii* (Kemmerling 1996). Di- and tri-fluoroacetate have recently been detected in *Gastrolobium* seed in record concentrations (Wang 2004), but are not recognised as significantly toxic. In a pilot study, one cat dosed under anaesthesia with a very toxic *G. parviflorum* seed ceased respiration in 82 minutes (Peacock *et al.* 2004), significantly slower than the ~25 minutes death of a dog reported by Webb (1885) and three cats dead in <1hr (Knight 1912).

Ecological Implications

Fox and cat predation are implicated as critical factors in the loss of CWR mammalian fauna throughout Australia, however a number of species have persisted better in south-west Western Australia than in any other region within the range occupied by foxes and cats in Australia.

Notwithstanding the benefit of toxic *Gastrolobium* in having 'a braking effect on land clearance' (Calaby 1971 p. 25), the reported toxicity of native fauna to introduced predators is considered likely to have had a significant role in this persistence. While *Gastrolobium* was still well distributed within the south-west it seems highly likely that species with extreme sensitivity to fluoroacetate, such as the dog, cat and fox (McIlroy 1981; Eason and Frampton 1991), would have been poisoned by predating toxic pigeons and marsupials, as described in these historical records. This is akin to secondary poisoning of foxes through scavenging 1080 poisoned rabbits (Algar and Kinnear 1996). Therefore, the suggestion that areas in the south-west where *Gastrolobium* remains common, such as the Perup and Dryandra Forests, confers a protective advantage (Anon. 1980; Christensen 1980b; Hopper 1991) is supported by the accounts presented in this paper, as it is by the statistical correlation between *Gastrolobium* and mammal diversity in conservation reserves (Short *et al.* 2005). Significantly, that study suggests that 'improved conservation of native mammals' may arise from 'greater knowledge of the role secondary poisoning (resulting from the presence of abundant and toxic species of *Gastrolobium* in the landscape)' contributes 'in limiting the distribution, abundance, and impact of feral cats' and foxes (Short *et al.* 2005 p. 35). Under the 'protective blanket' of current broad-scale fluoroacetate (compound 1080) fox baiting programs such as 'Western Shield' (Possingham *et al.* 2004), it seems likely that the restoration of this *Gastrolobium*/toxic fauna phenomenon would assist in the conservation of fauna in south-west Western Australia.

Although the recognised presence and action of fluoroacetate could explain many of these historical accounts, the accounts of rapid death are inconsistent with fluoroacetate poisoning. The speed of death in these accounts would need to be in significant error to be consistent with published fluoroacetate toxicity studies (Tourtellotte and Coon 1951; McIlroy 1981; Eason and Frampton 1991; Potter *et al.* 2006). Verification of the rapid toxicity stated by some historical pigeon accounts would better explain an anti-predator benefit to ingestion of the *Gastrolobium* seed material, notwithstanding any possible anti-parasite benefit (Dumbacher and Pruett-Jones 1996). It may be that fluoroacetate has unrecognised physiological behaviours, including a propensity for skeletal retention, or may be skeletally retained as its toxic metabolite fluorocitrate as per Peters *et al.* (1969). However, neither of these possibilities adequately explains the rapid death accounts. Although considered unwarranted and hence unlikely, another possibility is that these authors may have greatly exaggerated the time to deaths of their animals. A more likely hypothesis is that fluoroacetate is not the sole toxicant within *Gastrolobium* seed, with fluoroacetylated sugars, hypothesised by Hall (1972) and tentatively detected by Peacock (2003), a possible explanation.

Verification and identification of the reported rapid and bone-retentive toxicant(s) could potentially provide a tool and strategy to target those individual feral cats which can cause catastrophic predation (as distinct from surplus killing; Short *et al.* 2002) on native fauna, especially within reintroduction programs in areas distanced from *Gastrolobium* habitat (eg. Spencer 1991; Gibson *et al.* 1994; Christensen and Burrows 1995). For example, if fluoroacetate is the bone-retentive toxicant, providing greater temporal toxicity, then perhaps tolerant animals could be fed non-toxic doses of fluoroacetate before release, which would make them a toxic meal for foxes and cats. Feral cat predation previously recorded as extirpating a reintroduced population (eg. IUCN listed endangered greater stick-nest rats (*Leporillus conditor*) at Venus Bay, South Australia; Copley *et al.* 1999) may then, with death of the predator(s), be reduced to an isolated predatory event, able to be compensated by the species breeding recruitment.

Future management of *Gastrolobium* habitats, with an increased emphasis on the maintenance, restoration and re-establishment of *Gastrolobium* plants and thickets through appropriate fire regimes, is likely to aid survival of CWR mammals through improved shelter, food supply and secondary poisoning of introduced predators.

An interesting ecological question is however produced by the historical presence of dingoes (*Canis familiaris dingo*) in south-west Western Australia (Anon. 1911b; Warburton 1924). The dingo and dog have comparable extreme sensitivities to fluoroacetate (McIlroy 1981), therefore the dog poisonings and deaths from ingesting kangaroo and smaller marsupials reported in this study indicate that the dingo should have been similarly affected. Extensive research has been made on predator-prey relationships and the evolution of predator strategies and/or toxicant tolerance to deal with a prey's chemical defence (eg. Brower *et al.* 1968). Perhaps these dingoes became sensitive to fluoroacetate's irregular/seasonal presence in their prey, as found in experiments with *Sminthopsis crassicaudata* (Sinclair and Bird 1984), ignoring those animals which were toxic? Or it may have been that these dingoes simply avoided certain prey. Such avoidance could arise with a sub-lethal poisoning experience (Brower *et al.* 1968), akin to bait shyness in brush-tailed possums (Ogilvie *et al.* 2000), or possibly learned through the dingoes observation of poisoning in other dingoes. Alternatively, the dingoes may have moved their seasonal core activity areas (L. Allen pers. comm. 2008) during high toxicity periods such as *Gastrolobium* seeding and flowering, or temporarily moved from areas where dogs were being poisoned, as observed in the Northern Territory during a dingo 1080 baiting experiment after an application of non-toxic baits (D. Bermann pers. comm. 2008). Whatever the strategy, it seems likely that the presence of prey species toxic to the dingo must have had an impact either on its behaviour, or its distribution and abundance, in the south-west region. Additionally, it would be of interest to learn whether the toxic *Dichapetalum* plants of Africa (Grobbelaar and Marion Meyer 1989), and invertebrates that feed on fluoroacetate bearing plants, have any similar ecological influences. Of note is the observation that the caterpillars of *Sindris albimaculatus* that feed on the African fluoroacetate-producing *Dichapetalum cymosum*, accumulate fluoroacetate and are 'highly toxic to predators' (Meyer and O'Hagan 1992 p. 786).

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APPENDIX I

Appendix 1. Historical written accounts of toxic native animals and related issues, primarily from south-west Western Australia. I. Toxicity primarily attributed to tissue or bone retained toxicant.

Source	Anecdote Summary
Anon. (1841)	'Two ['quite young'] dogs belonging to Dr. Harris died the other day in consequence of eating the flesh of a goat [fed *Gastrolobium* leaves].'
Webb (1885)	Cooked bronezewing pigeon; dog ate breastbone and within 10 minutes was acting poisoned; dog made to vomit, but died within another 15 minutes; toxicity believed due to local pigeons eating almost entirely *G. bilobum* seed.
Campbell (1890)	Reporting on trip to Albany: 'My companion points out one of the poison bushes… scientifically known as Gastrolobium bilobum. Stock that eat thereof perish. Brush bronzewings readily devour the seeds without ill effect, nor is their flesh affected. But it has been affirmed that if cats eat the pigeons' bones they die.'
Mann (1906)	Cites a Mr E. R. Parker as stating that cats and dogs have been killed by the meat of pigeons which have been feeding on the seeds of *G. parviflorum*.
Anon. (1907a)	'It being the prevailing idea that opossum's are poisonous to members of the canine family, …'. Fed dog on cleaned and cooked opossum bodies for about a fortnight before the dog had a fit of madness and died. Was told that 'opossums lived by eating either box or York road poison plants, the poison was thereby communicated to the dog …'
Anon. (1907c)	Opossum shot in country with box poison in flower was gutted, skinned and cooked; hindquarters fed to sheep dog pup and forequarters to the cat at about 7pm; at about 9pm the cat ran away meowing loudly and disappeared; the dog soon afterwards began yelping and straining at its lead, went mad and soon died. 'My opinion is that the opossums caught in country with no poison plant on it will not poison a dog, and … they will not poison a dog if the poison plant is not in bloom or seed.'
Anon (1911a, b)	Evidence from numerous witnesses detailing *Gastrolobium* distribution and abundance, toxicity, eradication and seed longevity, as well as pigeons eating the seed and being poisonous.
Anon. (1912b)	In Broome lost cat then dog on separate days to 'table scraps', which included bronzewing pigeon and parrot bones.
Anon. (1912c)	'Commonly accepted statement here that the bones of bronzewing pigeons are poisonous.' Old timers around Albany consider bronzewing pigeon bones, that is bone marrow, to be poisonous.
Anon. (1917b)	Heard many times of someone losing a cat or dog from eating bronzewing pigeon bones. March 1916 shot pigeons at waterhole and 'removed feathers, crop and insides before taking them home'. Stewed birds and threw out bones which dog ate and then died before nightfall. Common bronzewing has become very scarce.
Anon. (1922d)	Three kangaroo dogs well fed with kangaroo meat, mostly cooked, some raw, went mad, ran around and then into the bush, or was shot.
Coff and Parker (1922)	Believes the toxicity of kangaroo and sheep meat is due to the blood containing the poison from *Gastrolobium*. Lost two dogs from eating the flesh of a poisoned sheep. Dogs and cats can be poisoned by the insides of native animals which eat poison, particularly when the plants are flowering and seeding.
Wansbrough (1922)	Lost dog with symptoms same as Anon (1922d), due to dog 'eating the bones of the small bronze-winged pigeon [*P. elegans*] that had been living on the seed of the box poison [*G. parviflorum*]'; knew of kangaroo dog poisoned by an opossum which had been feeding on *G. parviflorum* flowers.
Chitty (2004)	P. 105: 'Over the years, we lost good kangaroo dogs from eating poisonous sheep carcasses ... It only takes a small amount [of *Gastrolobium*] to kill an adult sheep and if a dog eats the carcass it goes mad and runs around until it drops dead ... I heard of a kangaroo dog going mad … before collapsing and dying.'
Cameron (2006)	G. Moore, 17th August 1834, p.336; 'Poor Mr Yule has lost two valuable dogs by licking the blood of the goats and sheep.' G. Moore, 3rd July 1838, p.447; 'Dogs which eat the flesh [of sheep affected] go mad'

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Appendix 1. Historical written accounts of toxic native animals and related issues, primarily from south-west Western Australia. II. Toxicity primarily attributed to gastro-intestinal tract (*Gastrolobium* seed or plant material *in situ*), or account indistinct, negative or related.

Source	Anecdote Summary
Anon. (1833)	Rumour of man and 2 dogs poisoned by eating mutton from 2 distempered [?*Gastrolobium* poisoned] sheep.
Brockman (1834)	W. L. Brockman, Herne Hill: 'dogs cannot eat of the carcase, or stomach – more particularly the latter – without danger of being affected in a similar manner with the sheep, no less than five of my neighbours' dogs having died from eating the carcases and insides of the affected sheep'
Drummond (1840)	State many believe bronzewing pigeons to feed on the seeds of the unidentified leguminous shrub, from a grove at King George's Sound 'with impunity, but dogs that happen to eat the stomachs and guts of the pigeons, die with the same symptoms with those that die from eating poisoned sheep and goats.'
Walter (1847)	The unidentified, poisonous leguminous plant, stated to grow 'to a height of three or four feet', is likely *G. calycinum*. ''The blossoms are also frequently eaten by animals [?possums]… When the seeds fall on the ground, the wild pigeons [*Phaps* spp.] greedily feed, and fatten on them; if the crops of these pigeons, consuming the seeds, be eaten by dogs, they die, yet the pigeons themselves, when dressed, are good food, and at that season are eaten in large numbers by the settlers. The flesh of sheep and cattle that have died from eating the plant, is poisonous if eaten raw by dogs, but when cooked, either by boiling or roasting, it ceases to be poisonous.'
Le Souëf (1900)	Cites WA sportsman whose retriever ate the intestines of shot *P. elegans*, which was full of *G. calycinum* seed, and was dead in under 20 minutes.
Anon. (1906)	States boodies bury wheat and poison seed; observed approximately 30 *G. calycinum* seedlings in one place from this behaviour.
Anon. (1907b)	While at Brookton and Pingelly in 1906, kangaroo dogs went mad and died from opossum entrails.
Anon. (1907d)	Considers only the opossum's nails and insides to be poisonous to dogs.
Anon. (1907e)	Killed opossums in *G. calycinum*, *G. parviflorum* and *G. parvifolium* country and never lost a dog; known dogs go mad and die from kangaroo rat insides.
Bert (1907)	Never heard of poisonous opossum meat; states aborigines and their dogs mostly live on opossum meat.
Clinch (1907)	Opossums in poison country poisoned dogs; opossums eat little *G. parviflorum* or *G. calycinum* foliage, mainly seeds; known dogs poisoned from eating sheep poisoned by *G. parviflorum* or *G. calycinum* plants.
Greig (1907)	Dog poisoned by eating a little opossum insides; four cats poisoned by eating one boody, plus 'several others since in similar way'; cats poisoned by bronzewing pigeons, which live largely on *G. parviflorum* and *G. bilobum* seeds; sheep dog poisoned from eating sheep poisoned by *G. calycinum*, *G. bilobum* or both; dog licked up kangaroo blood, soon acted poisoned, but vomited the blood and survived; known dogs to feed on opossums for weeks, but eventually they get a poisoned one.
Cairns (1909)	Cured poisoned staghound dog which had eaten boodie or opossum that had been feeding on *G. calycinum*.
Brown (1910)	States sheep that eat *G. parviflorum* will run until they die and if a dog eats some of the carcass it will also go mad and will bite anything.
Anon. (1912a)	Bronzewing pigeons are numerous in bush and often killed by flying into wires and their toxicity is accepted as an explanation of her earlier question (Anon. 1912d).
Anon. (1912d)	Questions whether bronzewing pigeons eating poisonous berries [?*Gastrolobium*] in summer could be poisonous to cats.
Knight (1912)	Three cats dead in <1hr from bronzewing pigeon insides when poison seeds are ripe 'while the people who ate the cooked pigeons were not affected'.
Anon. (1917a)	Around 50 years ago ate lots of common bronzewing pigeons, but burnt bones, insides and crop; bronzewings very fond of *G. parviflorum* seed; dogs and cats would die from the insides, not meat, of kangaroo rats.

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Anon. (1921a)	Around 1901 was grubbing *G. calycinum* on 'Yattah Block', a few miles out of Chidlow Wells [Chidlow]; little pet kangaroo would eat *G. calycinum* without any ill effect; kitten ate kangaroo meat cooked and raw without any ill effect; sheep in district were eating the poison bush and dying.
Anon. (1921b)	Used to mainly eat tammar wallabies, finding poison leaves in their stomach. Animals and chickens eating the insides were fine. State that for years they were unable to keep a cat. Always in late summer when the poison seeds were ripe the cats would become sick, vomiting up bronzewing pigeon feathers before they died. They observed no loss of cats during the rest of the year. They were able to save their cats if they gave the antidote [presumably potassium permanganate] with the first symptoms appearing. 'Sometimes the cat simply disappeared. Once we found two, one morning, dead outside the house with pigeon feathers nearby.' … 'We ate the pigeons ourselves, being careful to burn bones and insides, and never lost a dog. But the cats were nightly hunters and at that time the thick timber around harboured the bronzewings in great numbers.'
Editor (1921)	Heard kangaroo insides will send dog mad and bronzewing pigeon bones will kill dogs; has often seen dogs and chickens eat the insides of kangaroos without any ill effect.
Anon. (1922a)	States 'it is well known that dogs and cats go mad and run about after eating the inside of pigeons and kangaroos that had eaten poison plants [*Gastrolobium*].'
Anon. (1922b)	Believed dog died from eating opossum insides. Also heard of fox-terrier dying from eating a sub-adult bronzewing pigeon.
Anon. (1922c)	Has seen dogs go mad and run away and believes it to be due to them eating sheep poisoned by *G. parviflorum* or *G. calycinum*.
Anon. (1930)	Lost dog to entrails of sheep poisoned by *G. calycinum*.
Chewings (1930)	'I was surprised to find the natives knew the deadly nature of the plant [*G. grandiflorum*] so well. They will not camp under the bushes, and say that if they did harm would come to them. It is evident that the emu can eat the pods with impunity, for the seeds may often be seen in their droppings.'
Anon. (1933)	Believed dog died from eating a rabbit which had been killed by eating narrow-leaf poison (*G. stenophyllum*?). Died morning after eating rabbit, with about 3 hours from first symptoms to death.
Anon. (1934)	Dr S. W. Viveash, October 10th 1839; 'Got to Yangedin ['about 10 miles from York' = Yangedine] about 10 or 11. Heard that one of the Kangaroo dogs died from eating part of a goat that died suddenly [?from eating *Gastrolobium*]; the shepherd dog likewise very ill from the like case; he broke the rope which tied him & not heard of.'
Spencer (1966)	States opossums to have fed on *G. calycinum* and if fed to dogs to have caused them to go mad and die. Apparent reason for the name of Mad Dog Gully.
Erickson (1969)	Details early *Gastrolobium* toxicity trials by Drummond, Harris and Preiss. States Drummond 'may have had in mind the fact that Bronzewing pigeons were seen to eat the seeds of this plant ['a pea flower'] with impunity. However, he would be forced to admit that, although men could eat the flesh of these birds, when dogs were fed on the cast-off bones they were liable to die in sudden agony, suggesting poison.' Drummond is quoted as stating: 'Three valuable dogs were poisoned by getting at the guts of the sheep experimented upon (as well as one belonging) to a native …'.
Serventy and Whittell (1976)	'Lieut. H. W. Bunbury wrote of it [*P. chalcoptera*] as occurring in thousands in the summer of 1836.' *P. chalcoptera* and *P. elegans* 'are given to feeding on the seeds of the box-poison plant, *Gastrolobium bilobum*, and as a result their entrails and bones, but not the flesh, are poisonous to dogs and cats.'
Christensen (1978)	Observation of a dead fox in *G. bilobum* habitat, which, although there was no poison baiting, appeared to have been poisoned. States personal communication with Dr D. L. Ride, then Curator of the WA Museum, of pigs dying from ingesting woylies inadvertently trapped in rabbit traps. Suggests the protective benefit of *Gastrolobium* to native fauna in south-west Western Australia.
Stow (1981)	Comment from a trip by J. P. Stow from Perth to Albany in 1864: '… if a dog eats the entrails from a rat or wallaby that has so fed [on *Gastrolobium*] the effect is fatal…'
Shepherd *et al.* (1997)	Recorded *G. bilobum* in 67% of *M. fuliginosus*, 50 % of *M. eugenii*, 43% of *M. irma* and 40% of *Trichosurus vulpecula* scats.
Johnstone and Storr (1998)	*P. chalcoptera* and *P. elegans* – cites their previous abundance and *G. bilobum* and *Oxylobium* [WA species reclassified as *Gastrolobium*] respectively as dietary items.

APPENDIX 2

Appendix 2. Verbal accounts from people living in south-west Western Australia of toxic native animals and related issues

Source	Account
R. Erickson (*b.* 1908)	Bronzewing pigeons having toxic bones were mentioned to her by 'two turn of the century farmers of the Cranbrook district'.
B. de Burgh (*b.* 1912)	Heard from aunt farming ~21km east of Beverley in *G. parviflorum* country that if a cat ate a pigeon the cat would die from *G. parviflorum* seed eaten by the pigeon.
K. Smith (*b.* 1912)	An ex-dingo trapper who stated that he saw dead cats in the bush all his life. In 1928 he rode his horse through a 600m wide patch of *G. bilobum* on his property ('Karla Karllup', ~42km SE Bridgetown) and counted 13 dead cats, both fresh and old. He attributed their deaths to eating bronzewing pigeons which themselves had eaten the *G. bilobum* seed. He killed a few dogs by feeding them possums, which he said loved *G. bilobum* flowers and leaves, and there afterwards always removed all trace of guts and head. Knew old-timers who wouldn't eat bronzewings or parrots in poison bush country, and they told him Aboriginals wouldn't eat the bones of bronzewings or twenty-eight parrots [ringneck parrot, *Platycercus zonarius*].
A. Muir, (*b.* 1917)	On property ~56km from Manjimup, saw bronzewing pigeons feeding on *G. bilobum*. Heard that Aborigines would remove their crop first before feeding on them.
G. Warren, (*b.* 1917)	Grew up a few miles east of Narrogin on a property with no *G. parviflorum* or *G. bilobum.* Had friends and neighbours whose cats died from eating bronzewing pigeons. Stated this was due to the pigeons eating *Gastrolobium* seed. She cooked the pigeons for pigeon pie and stated everybody lived on pigeons or ringnecks [ringneck parrot, *Platycercus zonarius*].
W. Chitty (b. 1919)	Further to, and as per, his book (Chitty 2004): 'We had a good kelpie dog and big pup about June 1936… the dogs caught a small doe joey. I gutted it ... Just after breakfast the pup became very active. Father said he was poisoned … and [he] died from eating forepart. Old dog missing, he ate guts the night before. He was found dead at roadside ... Some years later I shot a very old grey doe and gave it to a woodcutter neighbor ... The dog was fed the kangaroo and went mad and died...' 'Native animals can carry a lot of poison ... We have eaten a few bronzewing pigeons. I was told not to let the cat eat the bones, the bones were poisonous. Bronzewings live a lot under tall old poison [*Gastrolobium*] plants and eat their seeds. Quales [Quails] also live on poison seed. I recall sowing clover on newly cleared land near a poison patch. Pidgeons [sic] soon found my clover seed and left their poison patch.' Additional comment: 'It takes very little poison to kill sheep or cattle especially in springtime.'
F. Boose, (b. 1921)	Heard of pigeons being poisonous and that Aboriginals wouldn't eat the pigeons
W. H. (Harry) Butler (*b.* 1930)	As a young man knew it as a matter of course that you didn't feed bronzewing pigeon bones to your dog. Old-timers said the poison was in the marrow. In March 1965 in Dryandra Forest, a *P. chalcoptera* was hit by the car windscreen and was cooked and eaten for the evening meal. *Gastrolobium* seeds (probably *G. bilobum*) were found in the bird's crop. The kids gave their bones to the young dog and within about 30 minutes it was convulsing, dying in another 10 minutes. Also told by Wongi Aboriginals at Warburton and Cundeelee to be careful of bronzewing pigeons. This was as a food and for a cultural reason [possibly their capacity to be poisonous].
G. McNeil (*b.* 1952)	Heard the bones of malleefowl were poisonous.