

# Effects of long-term fox baiting on species composition and abundance in an Australian lizard community

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**Abstract:** We report on the effects of almost a decade of 1080-fox baiting on a lizard community in a mosaic Australian habitat. Replicated comparisons of baited *versus* non-baited control areas with near-identical histories of bush fires, grazing and climate showed a higher density of red fox tracks (*Canis vulpes*) in the non-baited areas. Furthermore, the fox-baited areas showed a more than five times higher density of sand goannas (*Varanus gouldii*), a species that strongly overlaps the red fox in food niche breadth and is itself a direct target of fox predation, in particular its eggs and young. Exclusion of predators from a natural habitat led to significant increases in the density of small lizards, suggesting that predation can drive lizard population dynamics in this ecosystem. Replicated pitfall-trapping in three habitats in the control areas (with high fox and low goanna density) *versus* the baited areas (with low fox and high goanna density) showed that fox baiting had positive effects on the density of diurnal scincid lizards in open grassland, whereas the control areas showed higher density of nocturnal gecko lizards. Our interpretation is that fox removal may result in a shift in the top predator towards the sand goanna. Historically, this indigenous, endemic species was the natural top predator. It has co-evolved with its prey and that may have moulded it into a more efficient lizard predator per encounter than the introduced fox.

**Key words:** fox control, lizard community structure, pest management, species composition.

## INTRODUCTION

Australia is a continent plagued by deliberate or accidental introduction of numerous non-indigenous species through its 200 years of 'white history' (Caughley 1994; Burgman & Lindenmayer 1998; Long 2003). Vertebrate examples include rabbits, goats, foxes, cats, dogs, camels, buffalo, cane toads, feral pigs, deer and horses, and there are many examples of pest invertebrates and plants (Wilson *et al.* 1992; Burgman & Lindenmayer 1998). These introductions have led to losses of natural habitat, in particular through wide-ranging erosion by rabbits and goats, and have brought a number of species close to extinction through competition with introduced competitive ecological equivalents. For instance, the decline of the bilby (*Macrotis lagotis*) in Western Australia has been associated with rabbit (*Oryctolagus cuniculus*) expansion. Introduced animals have also led to diffuse selection in endemic fauna arising from multiple small niche overlaps (Wauters & Gurnell 1999) with ecologically similar

species such as the dietary overlap between burrowing bettongs (*Bettongia lesueur*) and rabbits (Robley *et al.* 2001).

One problem in understanding the impact of introduced species is that there is very little fine-grained information available on endemic species composition and abundance prior to pest introduction (Banks *et al.* 1998; Burgman & Lindenmayer 1998; Long 2003). We assume, however, that removal of introduced species will bring communities closer to a species composition that has been historically shaped by natural selection. However, we know little, or in most cases nothing, about what the relative proportions of taxa were in those co-evolved endemic communities. For example, introduced predators, such as foxes and cats, will have taken over the role of a generalist, top predator. Thus, if control programs reduce the impact of these exotic top predators, the endemic species composition will depend on what other species replaces the predator, and whether it is also an opportunistic generalist, or specializes on a few key prey taxa. In the present study, we designed sampling schemes and monitoring programs to analyse the effects of removal of an exotic top predator on an Australian lizard fauna.

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## METHODS

The study was designed to assess the effects of 1080-fox baiting by comparing baited *versus* unbaited areas in the semiarid shrublands of western New South Wales, Australia. We chose a replicated design with two independent sampling regions separated by >20 km within a baited area (Yathong Nature Reserve, 33°45'S 145°30'E). Anecdotal records suggested extremely high fox and cat abundance at the onset of the baiting program. Since its introduction in 1995, with irregular baiting intervals by road, and since 1997 complemented by three aerial baitings per year, the numbers of foxes have dropped significantly. Our analysis focused on the impact of fox reduction. Feral cats, which can also be severe predators on lizards, were not included since they were logistically difficult to sample, and are notoriously difficult to lure into taking baits (Molsher 2001; Short *et al.* 2002).

For comparison of communities where foxes remained, we sampled the lizard communities at two sites, 15 km apart, on the property Yara, 75 km west of Yathong, where fox baiting was not performed. Yathong and Yara have similar climates, and similar grazing and fire histories (B. Bloggs, pers. comm., 2002). Vegetation at both Yathong and Yara is a mosaic of spinifex (*Triodea*) desert, grassland (*Stipa*), mallee woodland (*Eucalyptus*), and rare stands of pine (*Callitris*).

### Fox sampling

Fox density was estimated by counting individual transient tracks (i.e. ones that did not interloop and/or were not connected) at six different randomly chosen sampling regions in sandy areas picked at random at Yara and Yathong. Although this sampling only took place in one habitat type, fox sightings in all habitat types during regular lizard surveys suggest that it was representative. Sampling at Yara took place on 15 January 2000, and at Yathong on 16 January 2000, performed by personnel at the Cobar office of the New South Wales National Parks and Wildlife Service. Each sampling region was about 1 ha, and was surveyed for approximately 1 h.

### Goanna sampling

Sand goannas (*Varanus gouldii*) grow to a size of about 100 cm total length, and weigh up to 2.0 kg. Because of their size they can easily escape out of pitfall traps and we therefore counted the number of goannas seen while driving at slow speed (*c.* 40 km h<sup>-1</sup>) on fire trails, roads and property boundaries at the two regions during days when goannas were active and during their

bimodal peaks of activity in the morning and evening. In total, 587 sampling km were covered at Yara, and 576 at Yathong between 10 November and 1 December 2000.

### Predation effects on lizard abundance

At Yathong Nature Reserve, a 400 m × 200 m area of natural habitat was fenced off in the mid-1980s to assist in reintroduction of mallee fowl (*Leipoa ocellata*), a threatened megapode in eastern Australia. Eight pens, 100 m × 100 m in a 4 × 2 design, were erected using chicken wire (with a diameter of 45 mm), and protected from climbing intruders by an electric deterring wire along its periphery. The pens were then used primarily to allow captive-produced mallee fowl chicks to adapt to their natural habitat. They were left to fledge through the open top of the pens. No disturbance of the natural habitat took place, and small lizards could freely pass in and out of the wire mesh. Vegetation and litter remained similar inside and outside the pens. Thus, these pens represent a natural habitat for lizards, free of predators for nearly two decades. We exploited this set-up to assess the impact of predation (mostly goannas in this fox-baited reserve), by sampling lizards in pitfall traps from 6 to 17 October 1999, on the inside of the pens, and in corresponding habitat immediately outside of the pens. Four pitfall trap lines were set up, two in spinifex habitat (14 m long, seven 20 L buckets each, one bucket every 2 m), and one trap line each in mallee and woodland (8 m long, four buckets, one every 2 m).

### Verifying goanna predation on small lizards

To investigate to what degree goannas prey on small lizards, we captured 34 adult goannas using a noosing rod, and used stomach flushing to determine gut content (Legler & Sullivan 1979; James 1991). The goanna was allowed to bite over a short plastic tube with a diameter selected to allow it to close its mouth comfortably. A silicone tube was then inserted through the tube into the stomach cavity and lukewarm water gently pumped down to flush out the stomach content. Goannas were paint marked with a non-toxic, human tattoo paint (Buck Spaulding, New York, USA) to avoid resampling.

### Sampling of lizard densities in natural habitat

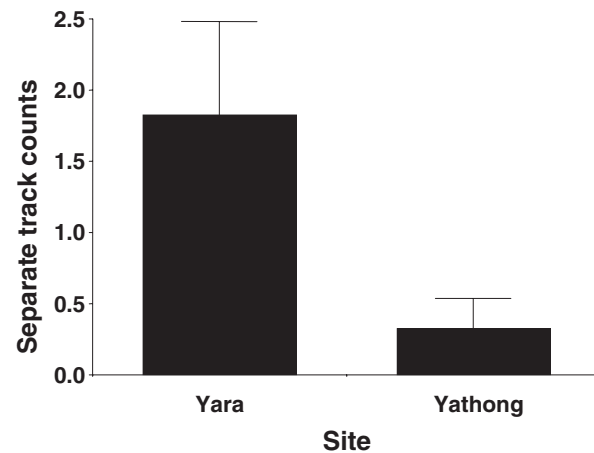
Both the baited and unbaited regions have three major habitat types, spinifex (*Triodea* sp. Bushes in sandy habitat, grassland and mallee woodland (predominantly eucalypts, *Eucalyptus socialis*, *Eucalyptus dumosa*

and *Eucalyptus gracilis* with some mallee pine, *Callitris preissii*). We trapped small reptiles over two replicated sampling regions (Yathong, Yara), and three habitat types (grassland, mallee/woodland and spinifex). At each trapping site, there were three trap lines (c. 15 m long, 0.5 m high drift fence of corrugated iron), each with five buckets (0.35 m diameter, 0.7 m deep, one every 2 m, plus 1 m ending fence). Thus, in total, each region was sampled using 90 pitfall traps, distributed along 270 m drift fence. Trapping was conducted for 11 consecutive days (from 24 November to 3 December 1999). Emptying of traps commenced at 6.00 hours, before bird and goanna predation could interfere with nocturnal sampling efforts, and with habitats and trap lines visited in random order. Fox prints were never observed near trap lines. Each reptile was identified and held until the sampling period was completed.

### Statistical analysis

The sampled lizard species showed great differences in activity between sampling events (days), depending on species-specific factors (e.g. nightly humidity in geckos). Generalist species characteristically may occur in all three habitat types, while specialists only occur in a single type of environment (e.g. some gecko species in spinifex communities). Therefore, rather than characterizing a species as, for example, a 'mallee/woodland' specialist based on published records, we let our data tell us in which habitat and on what particular night(s) a species was active. Only days when a taxon was successfully captured somewhere in either of the two sampling regions were entered into the analysis (hereafter referred to as a 'trapping event'). In those trap lines where none of this taxon was captured on one of those days, a score of zero was given. Thus, this generates a balanced data set, based on identical sampling effort at both regions, in which traps that generate zero captures on a given day or night at both regions for a given species are ignored (e.g. when environmental conditions are unsuitable for activity of that species regardless of its density and abundance).

At the onset of the study, our intention was to use factorial ANOVAs for analysing our data once sampling was completed. However, none of the sampling scores conformed to normal distributions, in spite of a number of attempts to transform them to normality (Wilk's lambda tests,  $0.46 < W < 0.77$ ,  $0.0001 < \text{Pr}:W_{\text{normal}} < 0.02$  for captures of all taxa, Proc Univariate Normal Plot, SAS). Since replicates did not differ significantly in captures (Wilcoxon two-sample tests,  $-1.29 < Z < 0$ ,  $0.08 < P < 1.00$ ), we pooled the two replicates per region (Yathong and Yara, respectively). Because of the problem with frequency distributions, we used non-



**Fig. 1.** Comparison of counts of fox tracks at Yara (unbaited) compared with Yathong Nature Reserve (baited). The six times higher count at Yara is statistically significant (Wilcoxon two-sample test, with continuity correction of 0.5;  $Z = 2.35$ ,  $P = 0.018$ ).

parametric techniques (Wilcoxon two-sample tests with continuity correction of 0.5, Kruskal–Wallis Analysis of Variance, Pitman's randomization test) on the pooled replicates per habitat for comparison of baiting regimes and for data pooled for taxonomic groups and/or habitats when appropriate.

## RESULTS

### Fox sampling

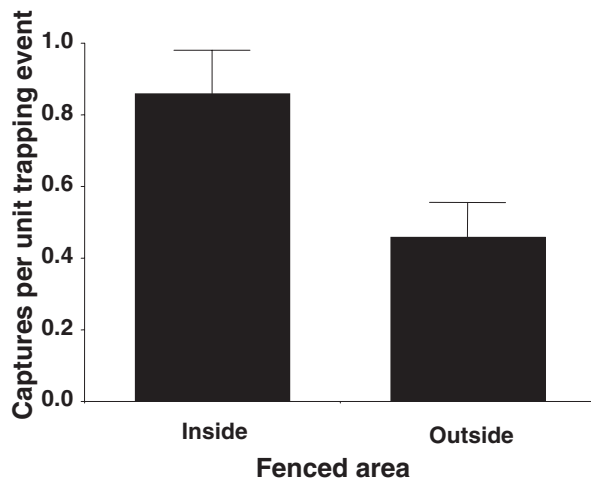
The average number of counts of fox tracks per sampling region was six times as high in the Yara region as in Yathong (Fig. 1; Wilcoxon two-sample test,  $Z = 2.35$ , d.f. = 1,  $P = 0.015$ ). This suggests that the long-term baiting program at Yathong effectively reduced foxes within the reserve.

### Goanna sampling

We observed nine goannas at Yara and 52 at Yathong over a slightly shorter sampling distance. This difference is highly statistically significant (Pitman's permutation test, exact two-sided inference,  $P = 0.00001$ ).

### Predation effects on lizard abundance

Inside the pens, we caught a total of 28 lizards, representing 11 different species. Outside the pens, we captured 13 specimens, representing eight species. Analysed as average number of captures for all species, captures inside were significantly higher than outside



**Fig. 2.** Total captures per species-specific trapping event in a 400 m × 200 m fenced off, undisturbed natural habitat, which (nearly) eliminates predation by goannas and foxes. The observed difference in trapping frequency is statistically significant (Wilcoxon two-sample test,  $Z = -2.26$ , d.f. = 1,  $P = 0.023$ ). For details on captured taxa, see Appendix I.

the fenced area (mean values  $0.86 \pm 0.13$ , SE, *vs.*  $0.46 \pm 0.10$ , Fig. 2; Wilcoxon two-sample test,  $Z = -2.26$ , d.f. = 1,  $P = 0.023$ ). We also attempted to analyse habitat-specific effects but our power was insufficient for mallee and woodland for such a comparison (too low sample sizes). In spinifex, however, the corresponding difference in trappability was highly significant ( $Z = 2.67$ , d.f. = 1,  $P = 0.007$ ). We also compared capture rates for the two major taxonomic groups (the families Gekkonidae and Scincidae) with data pooled across habitats. This revealed that there was no significant difference between inside and outside the fence for geckos (mean ± SE,  $0.71 \pm 0.21$ , and  $0.67 \pm 0.21$ , respectively; Wilcoxon two-sample test,  $Z = -0.09$ , d.f. = 1,  $P = 0.86$ ), whereas the corresponding scores for skinks were highly significant ( $1.19 \pm 0.16$ , and  $0.25 \pm 0.11$ ;  $Z = 3.91$ , d.f. = 1,  $P = 0.0001$ ).

#### Verifying goanna predation on small lizards

In 34 stomachs containing prey, nine (26%) contained lizards. At least three geckos were included, which apparently had been dug out of their burrows by the diurnally active goannas. However, because of the fragility of gecko skin, the exact number of geckos in the goanna stomach samples were hard to verify. Other lizards included were skinks and agamids (identified from skin samples).

#### Sampling of lizard densities in natural habitat

In Appendix I we report on all species recorded by us in activities at Yara and Yathong. Here we only report

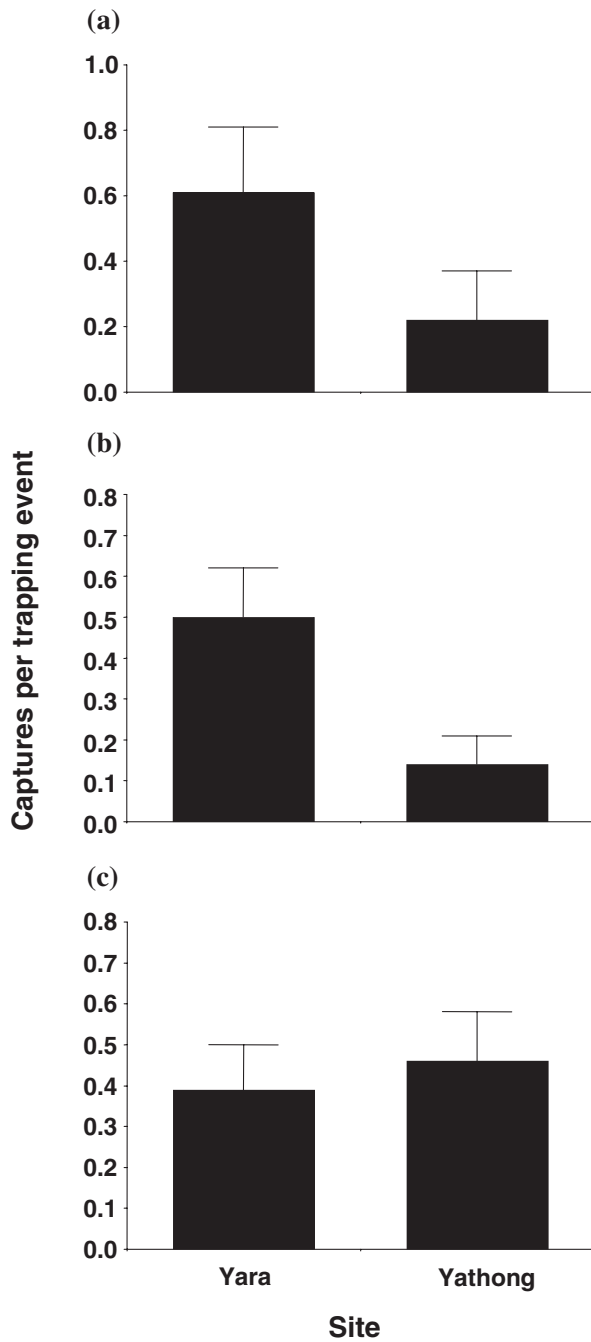
the outcome of the pitfall trapping. Based on total counts in pitfall traps across all habitats, there was no significant difference in the total number of trapped small lizards (mean ± SE,  $0.45 \pm 0.04$ , and  $0.37 \pm 0.04$ , for Yara and Yathong, respectively; Wilcoxon two-sample test,  $Z = -1.74$ , d.f. = 1,  $P = 0.08$ ). Furthermore, when we broke down the analyses to habitat level, there was no significant difference in total number of captures per trapping event in grassland (mean ± SE,  $0.37 \pm 0.08$ , and  $0.50 \pm 0.11$ , for Yara and Yathong, respectively;  $Z = 0.66$ , d.f. = 1,  $P = 0.50$ ), or spinifex ( $0.52 \pm 0.07$ , and  $0.39 \pm 0.06$ , respectively,  $Z = 1.28$ , d.f. = 1,  $P = 0.20$ ), whereas the corresponding figures for mallee/woodland were significantly higher at Yara than Yathong ( $0.41 \pm 0.06$ , and  $0.24 \pm 0.06$ , respectively,  $Z = 2.29$ , d.f. = 1,  $P = 0.022$ ).

Many of the taxa in our data set were represented by single captures of species for which there is relatively little information available on behaviour and ecology. Therefore, we also performed separate analyses on the two major families in our data set, geckos and skinks, from our sampling in the control and predator-reduced environments, which makes ecological and evolutionary inference possible. These analyses showed that for the nocturnal geckos, there was no difference in mean capture rates in spinifex, whereas in grassland and mallee/woodland, Yara exhibited significantly higher capture rates (Fig. 3a–c; see figure legends for test statistics). There was, however, one gecko species that reversed this trend. In the Yathong region, the knob-tailed gecko (*Nephrurus levis*) was captured significantly more often ( $Z = -3.46$ , d.f. = 1,  $P = 0.003$ ).

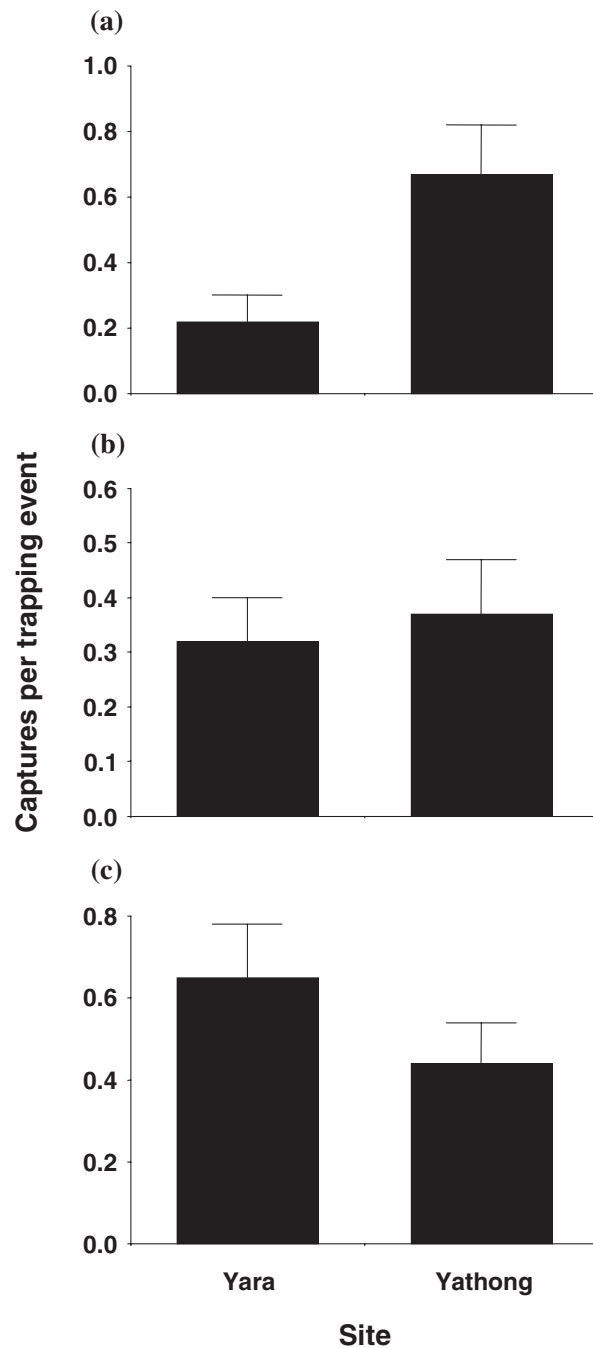
For skinks, an opposite result applied. In spinifex and mallee/woodland, there was no significant difference in mean capture rates between baited and unbaited areas, whereas in grassland, capture rates were three times higher in the unbaited region (Fig. 4a–c; see figure legends for test statistics).

## DISCUSSION

Our replicated sampling of fox tracks in the fox-baited *versus* unbaited areas in NSW lends support to the notion that a long-term baiting program resulted in a reduction in the numbers of foxes compared with the control regions. Admittedly, our point-sampling of foxes was limited and only aimed to support qualitatively, not quantitatively, the anecdotal observations of a drastic reduction of fox observations in response to the baiting program. The main goal of this study, however, was not to assess fox abundance *per se*, but to look for differences between the baited and the non-baited areas in terms of lizard fauna, and infer predator-prey population dynamics using our supporting



**Fig. 3.** Mean capture rates of geckos ( $\pm$ SE) in (a) grassland (Wilcoxon two-sample tests,  $Z = 1.95$ , d.f. = 1,  $P = 0.051$ ), (b) mallee/woodland ( $Z = 2.40$ , d.f. = 1,  $P = 0.016$ ) and (c) spinifex desert ( $Z = -0.35$ , d.f. = 1,  $P = 0.73$ ).



**Fig. 4.** Mean capture rates of skinks ( $\pm$ SE) in (a) grassland (Wilcoxon two-sample test,  $Z = -2.57$ , d.f. = 1,  $P = 0.01$ ), (b) mallee/woodland ( $Z = -0.07$ , d.f. = 1,  $P = 0.94$ ) and (c) spinifex desert ( $Z = 1.05$ , d.f. = 1,  $P = 0.29$ ).

predation experiment. An obvious question, then, is 'to what degree is our study robust enough to allow general conclusions with respect to predator-prey relations between species?'

In this study, it quickly became apparent that goannas were much more common at Yathong than at Yara. One explanation for this is that the habitat at Yathong

was more suitable in some way for goannas. However, the two regions are very similar in substrate, vegetation, climate and grazing histories. A more likely explanation is therefore that the decrease in fox numbers has allowed the goanna population to increase. This may either result from reduced fox predation on goanna eggs and juveniles, or from a release from

competitive pressure. It is well known from the literature that goannas are opportunistic feeders with small lizards as a natural part of their diet (Shine 1986; Cogger 2000). This was confirmed by stomach content analysis in the present study. Thus, careful sampling of goanna densities is necessary to make possible any kind of assessment of the effects of the fox reduction on lizard biodiversity. Goanna predation might mask any differences in lizard abundance resulting from reduced fox density. However, fluctuations in population density can come about through a variety of factors, most notably perhaps variation in food availability. Thus, to establish that goanna predation can regulate small lizard density, we exploited enclosed natural habitat, with fences erected some two decades before this study was conducted and, hence, with ample time for lizard populations to establish equilibrium density levels. Using this set-up, we were able to confirm that in the predator-reduced environment inside the enclosure, capture rates of lizards were significantly higher. In total, more than twice the number of specimens, and almost 40% more species, were captured in the predator-reduced environment. Since foxes were only reduced in numbers, not eliminated, and cats are little affected by the baiting program, we certainly do not claim that this result is due entirely to goanna predation. However, most of the successful sampling in this experiment took place in spinifex, and this environment has the lowest relative encounter rate of foxes of the three habitats in this study (Catling & Burt 1995), and the highest encounter rate of goannas (Olsson *et al.* pers. obs. 1997–2005; Cogger 2000). Thus, we are confident that goannas represent a significant predator on small lizards in this experiment, and that this at least partly explains the higher lizard counts in the predator free environment.

The main part of our study, the pitfall sampling of the small lizard populations in the baited *versus* unbaited areas, was based on a replicated factorial design, intended to be analysed with a parametric analysis of variance. This proved impossible because of the skewed frequency distributions for capture rates for all species (and for total captures) that could not be transformed to normality. It is also notable that there were no statistically significant differences between replicates within regions, which seems to demonstrate that the sampled areas within regions represented region-specific habitat types well. This also lent support to the notion that differences between regions were robust estimates of differences in true lizard densities.

Any study of this kind is prone to confounding effects of among-region differences in selection history, such as those arising from grazing and bush fires. In the present study, grazing regimes in all replicated sampling areas have been similar for more than 30 years with no agricultural grazing, and with no bush fires taking place for the last decade. Prior to

that, Yathong was partly burnt in 1984, whereas Yara had bush fires in the late 1960s. An obvious question is whether this difference in fire history inflates the effects of fox baiting on ecosystem differences between regions in our study. We doubt this for the following reasons: (i) Recovery rate to carrying capacity is dependent on generation time and fecundity. In our study, the lizard species that showed the greatest difference between regions, being five times more common in the fox-reduced habitat, was the sand goanna, the species with the longest generation time of all the species in this study (Greer 1989; Cogger 2000). Thus, it appears much more likely that difference between regions is due to some other factor than fire history. (ii) Lizard survival is generally considered high during fires, and fire can sometimes even elevate abundance, at least when fires are of moderate heat (Cogger 1969; Cheal *et al.* 1979; Longmore & Lee 1981). For most species in this study, a decade represents some 10 generations (most small species of skinks and geckos in this study would, under average climatological circumstances, be annuals), and, hence, there appears to have been ample time to restore any losses in density subsequent to the fires and time for adequate regeneration of habitat for normal patterns of diversity (Caughley 1989).

Under the hypothesis that the observed differences in lizard numbers between baited and control areas are primarily explained by factors related to the induced reduction in fox numbers, some of our observations follow logically from this scenario, whether others show inconsistencies. For scincid lizards, capture rates in grassland were significantly higher in baited than control plots. Grassland is the prime fox habitat. Thus, this is consistent with the idea that fox removal aids lizard survival in this habitat. The question then arises, 'why does not the same scenario apply to geckos?' A plausible explanation is that goannas are better equipped to dig out burrowing nocturnal geckos during day time in the hard, dry ground most often experienced in grassland and mallee/woodland. Support for this comes from our observations of both gut contents of sand goannas, where small nocturnal geckos were present, and direct observations of goannas digging out lizards hiding in their burrows during the day. If this hypothesis is correct, the shift from foxes as top predators to goannas in response to fox baiting would also mean a reduction in some prey species of goannas, perhaps notably geckos. If so, it is important to build a solid understanding of species relationships before *versus* after baiting, at low *versus* high densities of goannas, and with detailed insight into their foraging ecology and prey shifts in relation to prey abundance.

In summary, our study shows that fox baiting over the last decade has had some predictable, fortunate effects on fox and lizard abundance. However, in most work of this kind, budgeting is restrictive enough to

preclude monitoring work before and after executive measures are taken to remove introduced pest species. Our conclusion is that this is a drastic mistake if we aspire to understand the consequences ecosystem wide of our bioconservation investments. Therefore, we may be surprised at finding shifts in the abundance of species at lower trophic layers, as a consequence of reinstating indigenous top predators with, unlike introduced pests, a co-evolutionary history with their prey. If this is the case, a historically natural balance is also reinstated. More future work is clearly required to validate this statement, and our recommendation is that stringent monitoring is made a standard component in every pest management program.

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### REFERENCES

- Banks P. B., Dickman C. R. & Newsome A. E. (1998) Ecological costs of feral predator control: foxes and rabbits. *J. Wildl. Manage.* **62**, 766–72.
- Burgman M. A. & Lindenmayer D. B. (1998) *Conservation Biology for the Australian Environment*. Surrey Beatty and Sons, Sydney.
- Catling P. C. & Burt R. J. (1995) Why are red foxes absent from some Eucalypt forests in eastern New South Wales. *Wildl. Res.* **22**, 535–46.
- Caughley J. (1989) Effect of fire on the reptile fauna of the mallee. In: *Biology of the Australasian Frogs and Reptiles* (eds G. Grigg, R. Shine & H. Ehman), pp. 31–4. Royal Zoological Society of New South Wales, Surrey Beatty and Sons, Sydney.
- Caughley G. (1994) Directions in conservation biology. *J. Anim. Ecol.* **63**, 215–44.
- Cheal P. D., Day J. C. & Meredith C. W. (1979) *Fire in the National Parks of North-west Victoria*. National Parks Service, Victoria.
- Cogger H. G. (1969) A study of the ecology and biology of the mallee dragon (*Amphibolurus fordii*) and its adaptations to survival in an arid environment (PhD Thesis). Macquarie University, Sydney, Australia.
- Cogger H. G. (2000) *Reptiles and Amphibians of Australia*, 6th edn. Reed New Holland, Sydney.
- Greer A. E. (1989) *The Biology and Evolution of Australian Lizards*. Surrey Beatty and Sons, Sydney.
- James C. D. (1991) A refinement of the stomach-flushing technique for small scincid lizards. *Herpetol. Rev.* **21**, 87–8.
- Legler J. M. & Sullivan L. J. (1979) The application of stomach flushing to lizards and anurans. *Herpetologica* **35**, 107–10.
- Long J. L. (2003) *Introduced Mammals of the World: Their History, Distribution and Influence*. CSIRO Publishing, Collingwood.
- Longmore R. & Lee. P. (1981) Some observations on techniques for assessing the effects of fire on reptile populations in Sturt National Park. *Aust. J. Herpetol.* **1**, 17–22.
- Molsher R. L. (2001) Trapping and demographics of feral cats (*Felis catus*) in central New South Wales. *Wildl. Res.* **28**, 631–6.
- Robley A. J., Short J. & Bradley S. (2001) Dietary overlap between the burrowing bettong (*Bettongia lesueur*) and the European rabbit (*Oryctolagus cuniculus*) in semi-arid coastal Western Australia. *Wildl. Res.* **28**, 341–9.
- Shine R. (1986) Food habits, habitats and reproductive biology of four sympatric species of varanid lizards in tropical Australia. *Herpetologica* **42**, 346–60.
- Short J., Turner B. & Risbey D. (2002) Control of feral cats for nature conservation. III. Trapping. *Wildl. Res.* **29**, 475–87.
- Wauters L. A. & Gurnell J. (1999) The mechanism of replacement of red squirrels by grey squirrels: a test of the interference competition hypothesis. *Ethology* **105**, 1053–71.
- Wilson G., Dexter N., O'Brien P. & Bomford M. (1992) *Pest Animals in Australia: A Survey of Introduced Wild Mammals*. Bureau of Rural Resources, Canberra.

### APPENDIX I

#### Lizard species list of Yathong and Yara, respectively

Species	Yathong	Yara
<b>Scincidae</b>		
<i>Ctenotus allatropis</i>	C	C
<i>Ctenotus atlas</i>	C	C
<i>Ctenotus schomburgkii</i>	C	C
<i>Ctenotus robustus</i>	N	C
<i>Cryptoblepharus carnabyi</i>	C	C
<i>Egernia inornata</i>	C	N
<i>Egernia striolata</i>	N	C
<i>Lerista muelleri</i>	C	C
<i>Lerista punctatovittata</i>	C	C
<i>Menetia greyii</i>	N	C
<i>Morethia boulengeri</i>	C	C
<b>Gekkonidae</b>		
<i>Diplodactylus intermedius</i>	C	C
<i>Diplodactylus steindachneri</i>	C	N
<i>Diplodactylus vittatus</i>	N	C
<i>Gehyra dubia</i>	(C)	N
<i>Gehyra variegata</i>	(C)	N
<i>Heteronotia bionei</i>	(C)	N
<i>Lucasium damaeum</i>	C	C
<i>Nephruirus levis</i>	C	C
<i>Rhynchoedura ornata</i>	C	N
<i>Underwoodisaurus millii</i>	C	C
<b>Pygopodidae</b>		
<i>Delma butleri</i>	C	N
<i>Delma inornata</i>	N	C
<b>Agamidae</b>		
<i>Amphibolurus nobbi</i>	N	C
<i>Ctenophorus fordii</i>	C	C
<i>Ctenotus pictus</i>	C	N
<i>Pogona vitticeps</i>	(C)	(C)
<b>Varanidae</b>		
<i>Varanus gouldii</i>	(C)	(C)
<i>Varanus varius</i>	(C)	N

Capture records within parentheses indicate visual observation. C, captured; N, not captured.