Shape and spatial distribution of Mulgara (*Dasycercus cristicauda*) burrows, with comments on their presence in a burnt habitat and a translocation protocol

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Abstract

The Crest-tailed Mulgara (*Dasycercus cristicauda*), a species listed as vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act (1999) and as a Schedule 1 species under the Western Australian Conservation Act (1950), was once found throughout arid central Australia and Western Australia, but its geographic range has been significantly reduced. The spatial distribution and shape of Mulgara burrows is described for an area that was subsequently cleared in the Pilbara of Western Australia. The area contained a substantial cover (» 50% cover) of spinifex (*Triodia* sp.) tussocks to about 600 mm high and scattered shrubs when first searched in June 2006 but had been burnt (November 2006) by the time Mulgara were to be translocated before the vegetation was cleared in January 2007. Burrows contained between two and nine entrances, tunnels were mostly on a single level and to a depth of about 300 mm. The lumen for a burrow entrance was typically an arch over a flat bottom with a height of 70–80 mm, and a width of 80–100 mm at the base. Internal tunnels were mostly 50–70 mm wide. Burrows entrances in the burnt landscape were mostly in the open. There was one burrow per 2.5 ha in the area searched, but this was probably a 'hot-spot' for Mulgara for the region. Four Mulgara were caught in 750 Elliott trap-nights and five by digging out 65 recently active burrows in an area of about 22 ha. From this we concluded that a substantial trapping effort was required to trap all the Mulgara in an area. If Mulgara are being translocated from an area, then we would recommend an intensive trapping program combined with searching for and digging out all recently active burrows in the area. Strategies to enhance the capture of Mulgara are discussed.

Keywords: Mulgara, *Dasycercus cristicauda*, burrows, Pilbara, Western Australia

Introduction

Two species of Mulgara are currently recognised, the Crest-tailed Mulgara (*D. cristicauda*) and the Brush-tailed Mulgara (*D. blythi*: Woolley 2005). As this taxonomic change was recent, it is likely earlier reports on Mulgara referred to one or both species. This paper discusses the shape and spatial distribution of Crest-tailed Mulgara burrows.

Mulgara are generally sedentary in contrast with some other small dasyurids and have high site fidelity and a low propensity for dispersal once a home range has been established (Masters 1998, 2003; Dickman *et al*. 1995). Home ranges vary in size from 1.0 to 14.4 ha (mean 6.5 ha, Masters 2003), with some overlap.

Both males and females use 2–9 burrows, but average about three (Masters 2003). Burrows are mostly used by a single individual, but males and females have been found together in a single burrow during the breeding season (Masters 2003). An individual's burrows are likely to be concentrated in a relatively small area as the average maximum distance across a home range is about 440 m (Masters 2003). Woolley (1990) described *D. cristicauda* burrows near Ayers Rock as having one large hole, around which there was loose soil, and either one or two smaller holes within 1 m of the large hole. The tunnels to these pop holes were near vertical. Tunnels in these burrows led to a grass-lined nest at a depth of about 0.5 m. Each of these burrows contained a female with pouched young. Strahan (2000) suggested that the complexity of burrows varies geographically with those in central Australia having a single entrance with two or three side tunnels and pop holes, and those in Queensland having more than one entrance, deeper branching tunnels and numerous pop holes. This difference may have been due to differences in species that were not recognised until recently. It is therefore apparent there are limited data in the literature that describe the shape of Mulgara burrows and there is nothing on their spatial distribution.

Masters *et al*. (2003) reported that *D. cristicauda* can tolerate a moderate local reduction of vegetation cover, but suggested that a more severe reduction could result

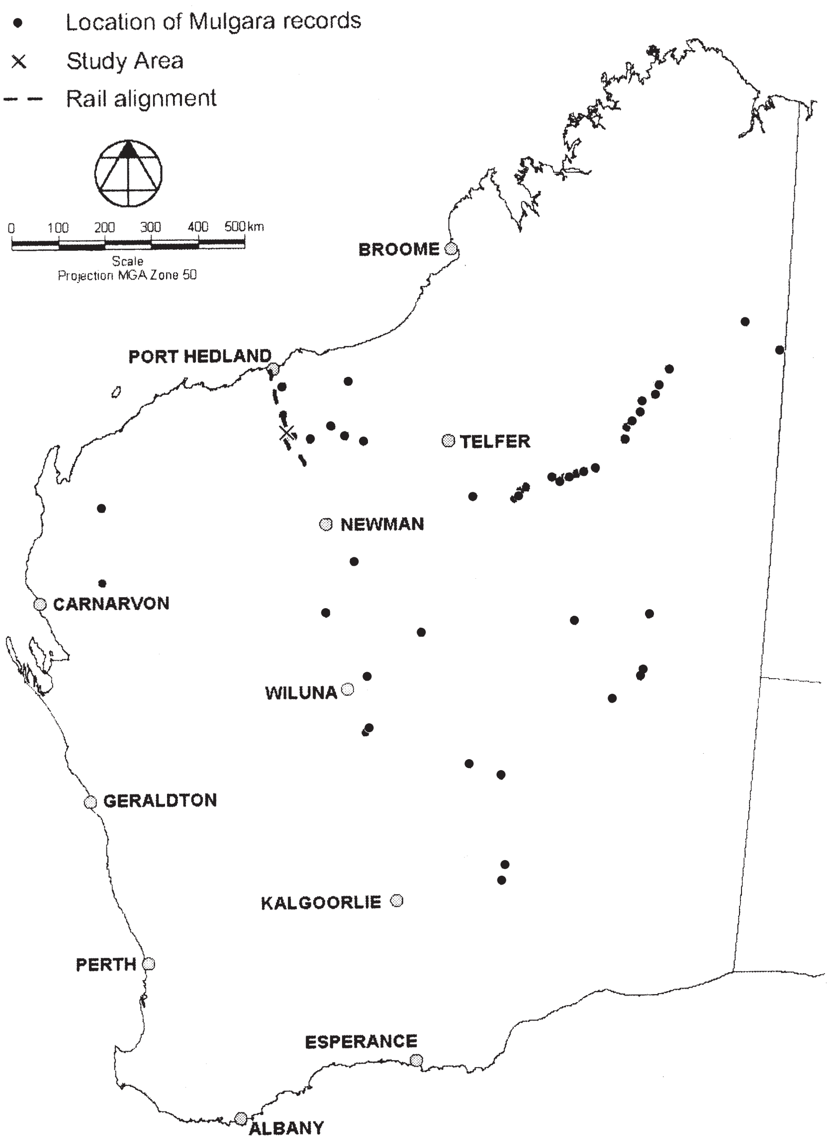

Figure 1. Capture locations of Mulgara in the Western Australian Museum collection, location of the Fortescue Metals Group railway line corridor and the location of the study site (marked with an X).

in a population decline (Masters 1993). In contrast, in this investigation we report on numerous active burrows in an area that had been burnt and was largely devoid of vegetation. Staff in Fortescue Metals Group indicated that the area was burnt during the early part of November 2006.

This case study focuses on a particular site that was to be cleared once Mulgara had been translocated. Fortescue Metals Group is constructing a railway line from Port Hedland to their Cloud Break mine about 260 km to the south (Figure 1). In order to meet its environmental obligations the proposed railway line corridor and the associated borrow pits were searched between June and October 2006 to identify areas that might contain species of conservation significance including *D. cristicauda*. Areas recorded as containing species of conservation significance [Mulgara are listed as vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act (1999) and as a Schedule 1 species under the Western Australian Wildlife Conservation Act (1950)] were again searched in December 2006 and January 2007 with the purpose of relocating individuals before clearing commenced (Table 1).

This paper reports on the shape and spatial distribution of Mulgara burrows in an area to be cleared, their presence in a burnt habitat and a protocol for catching Mulgara when they need to be translocated out of an area that is to be cleared.

Table 1

Sequence of search and trapping activity.

Date	Activity
26 June 2006	Searched the area – 22 person hrs
November 2006	Area burnt
20 December 2006	Searched the area
5–10 January 2007	Site was trapped, searched and all recently active burrows dug out

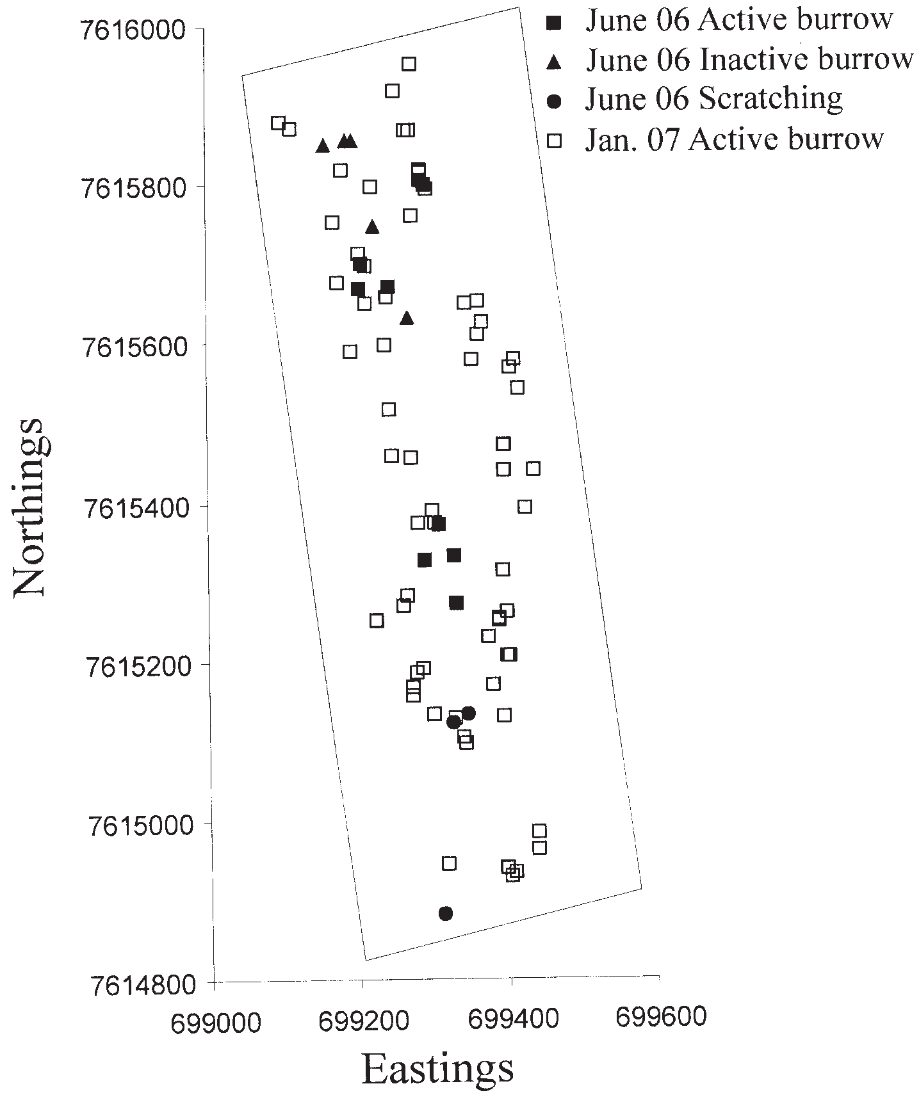

Figure 2. The parallelogram indicates the size and location of the area intensively searched and the location of burrows and scratchings detected in the June 2006 and dug out in January 2007.

Methods

Study site

The area intensively trapped and searched was a parallelogram of about 1100 m by 400 m on the Fortescue Metals Group railway line corridor (Datum WGS 84, UTM 50 699200E 7615700N; Figures 1 and 2). The site was vegetated with a substantial cover (» 50% cover) of spinifex (*Triodia* sp.) tussocks to about 60 cm high and scattered shrubs on a substrate of gritty red sand when first surveyed in June 2006 (Figure 3). It was to be cleared once the Mulgara in the area had been translocated.

Surveys

During June 2006, this site was systematically searched for Mulgara burrows, diggings and scats (Table 1). This involved five people walking in a line approximately 20 m apart up and down the site on four occasions (22 person hrs). The location of all active and inactive burrows, diggings and scats was recorded with a GPS. The area was well vegetated with spinifex and not all burrows would have been detected.

A pre-clearing survey was undertaken on 20 December 2006 to determine whether *D. cristicauda* burrows were still being actively used. Between 5–10 January 2007, 150 Elliott traps baited with peanut butter, rolled oats and sardines were deployed around the 22 ha site. These traps were left open for a period of five nights, a total of 750 trap nights. During that same period the entire area was systematically searched by up to four people on four occasions looking for recently active burrows. A recently active burrow was defined as one that had obvious signs of mammal movement around the entrance. Often there were multiple entrances to a burrow complex but only one entrance needed to show signs of recent activity for the burrow complex to be recorded as being active. All recently active burrows were excavated between 7 and 10 January 2007, initially by shovel to remove the surface soil and then by hand.

The dimensions of three burrows that contained

Mulgara were measured and have subsequently been drawn as figures. The location of all recently active burrows recorded during January 2007 was recorded with a GPS.

Results

In November 2006 the area was extensively burnt presumably from lightning strikes leaving a few isolated clumps of spinifex in a flat barren landscape that contained the occasional burnt trunk of shrubs and small trees. Figure 3 includes an image of the site that was taken in June 2006 and in January 2007. By January 2007 many of the small trees had begun to sprout leaves. During the June 2006 pre-burn search nine recently active burrows, five inactive burrows and three Mulgara scratchings were recorded (Figure 2). When the area had been burnt and recently active burrows were more easily identified, 65 were located.

Four Mulgara were caught in Elliott traps and five were dug from their burrows. Two of the Mulgara were mature adults (male 91 g, female 70 g); the other six weighed were three males with a body mass of 49, 39 and 52 g and three females with a body mass of 37, 44 and 34 g; and one individual was not sexed or weighed.

The area searched and location of each of the recently active burrows recorded during the June 2006 and January 2007 surveys are shown in Figure 2. The plan and elevation of three burrows containing Mulgara are shown in Figures 4–6. Recently active excavated burrows had either no pile of soil or a flattened pile less than 20 mm high making them difficult to detect from a distance (Figure 3).

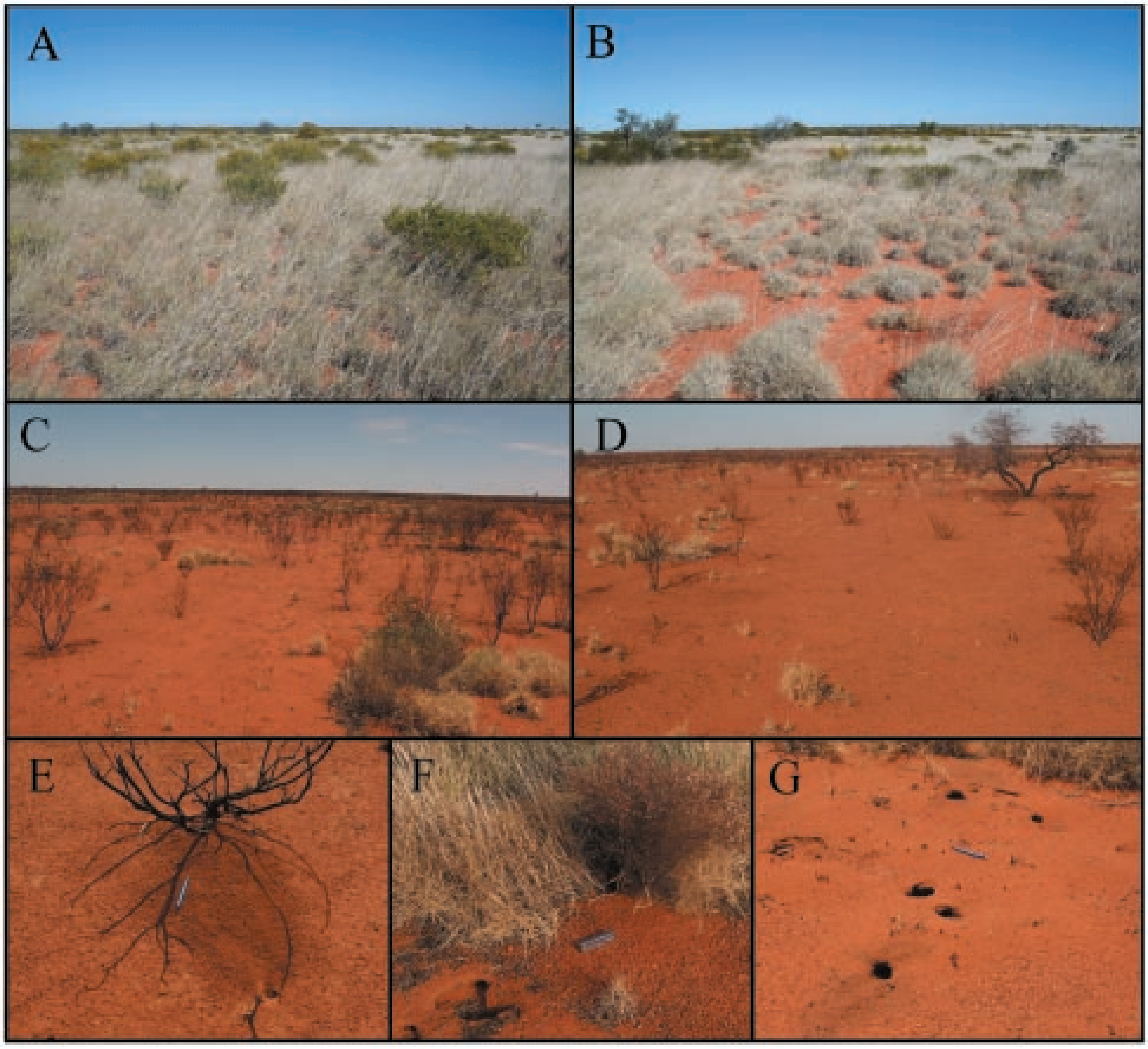

Figure 3. A and B show the habitat in June 2006 prior to burning; C and D show the habitat in January 2007 post burning; E, F and G show burrow entrances.

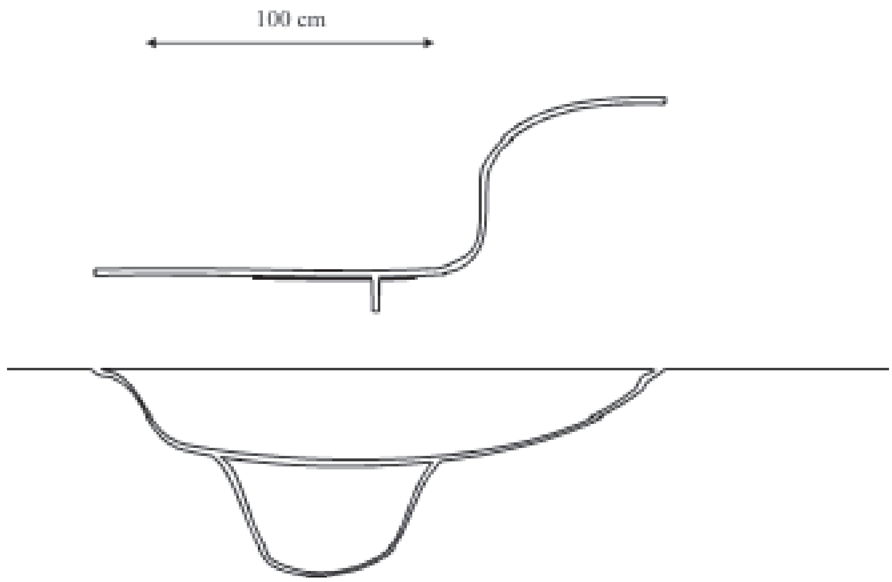

Figure 4. A plan and elevation of a burrow. The elevation is drawn as a casting with the surrounding soil being removed but a cross-section of the surface soil shown.

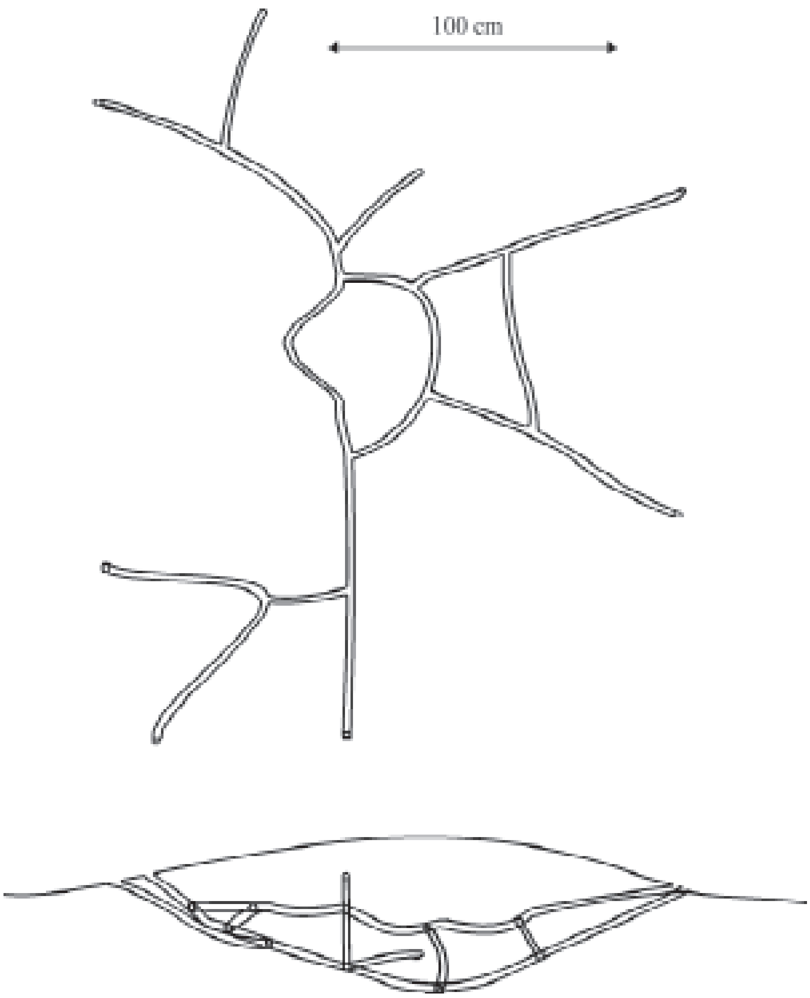

Figure 5. A plan and elevation of a burrow. The elevation is drawn as a casting with the surrounding soil being removed but a cross-section of the surface soil shown.

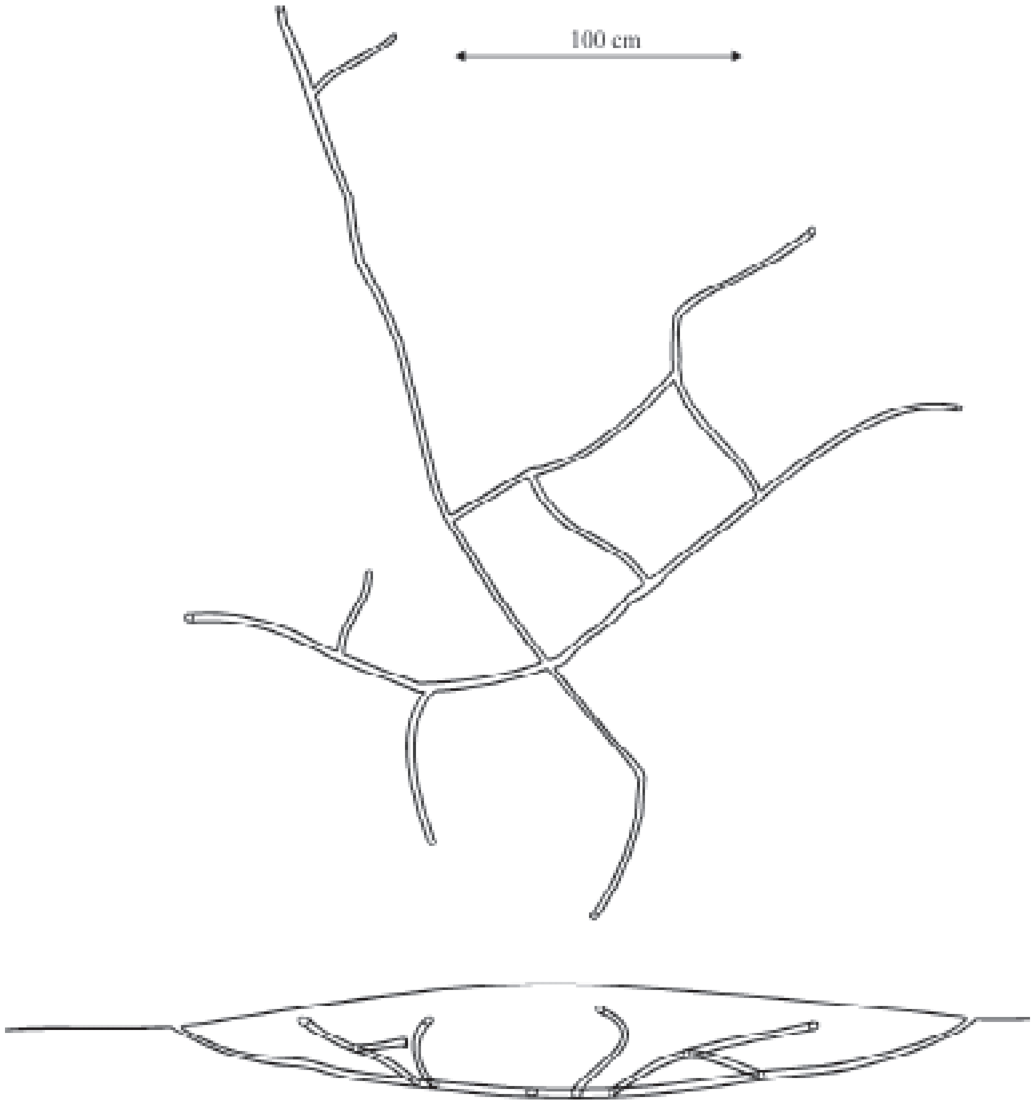

Figure 6. A plan and elevation of a burrow. The elevation is drawn as a casting with the surrounding soil being removed but a cross-section of the surface soil shown.

Based on the presence of a disturbed mound of soil at the burrow entrance, only two burrows had been recently dug out. Only six burrows were adjacent to a spinifex bush, all others were in the open (Figure 3, E, F and G). The complexity of burrows varied. Figures 5 and 6 show two of the more complex burrows. Some of the burrows were of a simple configuration with two entrances and a single joining tunnel or had one short blind tunnel leading off the main tunnel. Other burrow complexes had up to nine entrances. Burrows of a simple design and with few entrances mostly had a small mound of soil around the entrances (< 50 mm high), and some had no detectable mound of soil at all (Figure 3). None had a vertical shaft leading to a pop hole. Only two burrows contained tunnels that formed two levels, and one of these contained two Mulgara (Figure 4). The male was located in the blind spur off the tunnel closest to the surface and the female was in the deepest part of the lower tunnel. It should be noted that it takes up to an hour to excavate a burrow system and Mulgara probably move around the tunnels while the digging is going on so the capture location may not be where these individuals spent their day.

The lumen for a burrow entrance was typically an arch over a flat bottom with a height of 70–80 mm, and a width of 80–100 mm at the base. However, there was considerable variation with some entrances in a burrow complex looking very similar to that dug out by a *V. gouldii* which is much wider and not as high. Some burrow complexes contained entrances that were much smaller than these dimensions (*i.e.* 50–60 mm by 50–60 mm).

Internal tunnels were typically 50–70 mm wide. The deepest tunnel shown in Figure 3 was one of the narrowest excavated at 40 mm wide. Some burrow complexes contained enlarged sections, and these were mostly at the junction of tunnels. From the tracks around the burrow entrances, it appeared as if only a few of the entrances were in current use when there were up to nine entrances for some burrows. The deepest tunnel was generally less than 300 mm below the 'true' ground surface level, but mounds around burrow entrances meant that burrows could be up to 550 mm below the surface immediately above the deepest section of the burrow. Most burrows had only one level for all the tunnels. The burrow shown in Figure 4 is one of two burrows with two levels; the deepest section was approximately 650 mm below the surface and the other tunnel was about 250 mm below the surface at its deepest parts.

A *V. gouldii* (SVL » 200 mm) was found in one burrow complex with a Mulgara. This burrow was dug out at about 07:30 hr and the *V. gouldii* was very sluggish in its movements indicating that this was the burrow it had occupied the previous night. Two other burrows not containing Mulgara contained *Egernia striata*, one burrow contained five *Nephrurus levis,* one contained two *Pseudomys hermannsburgensis* and one contained a *Varanus eremius*. Elliott traps also caught two *Pseudomys hermannsburgensis* and one juvenile *V. gouldii* in addition to Mulgara.

Discussion

Masters *et al*. (2003) reported that harvesting (cutting the tops off all spinifex to a height of 15 cm) had no significant impact on the abundance of Mulgara in the arid desert around Ayers Rock, but Masters (1993) suggested a severe reduction in the vegetation could result in a population decline. Invertebrate biomass remained unchanged in the experimental plots of Masters *et al*. (2003); however, the mowing of the vegetation resulted in a significant reduction in the number of rodents caught in their study plots. In contrast with the findings of Masters (1993), our study site was burnt in November 2006, and it appears that Mulgara in the area did not move out of the burnt area. Immediately to the east of our study site there was an area which was not burnt and contained a dense cover of spinifex, and there was another area about 2 km to the north that was densely vegetated with mature spinifex on a sandy substrate. Both of these sites would seem to offer suitable alternative locations had the Mulgara wanted to move after the fire. These data suggested that Mulgara had adapted to the short term impacts associated with the removal of vegetation by fire.

There was no obvious clustering of recently active burrows within the area searched, however, it did appear as if there was a distinct linear orientation to the placement of burrows (Figure 2), as there were few burrows on the periphery of the area searched. A less intense search of the area outside the polygon (Figure 2) found no burrows. Some active burrows were located within metres of others (Figure 2) and there were some patches devoid of burrows. We could see no obvious reason for their specific locations; however, it may have reflected the presence of vegetation before the area was burnt.

The burning of the area made it much easier to locate burrows. As there was no evidence to indicate that new burrows had been dug (*e.g.* large piles of freshly disturbed soil at the burrow entrance) since the fire, we presumed that most of the burrows assessed as recently active went undetected in the June 2006 survey. Even when the area had been burnt the search effort to locate all recently active burrows was substantial (*i.e.* up to four persons on four separate occasions) indicating how difficult it was to locate some burrows.

Woolley (1990) and Triggs (2004) showed pictures of Mulgara burrows with substantial piles of soil around the entrance, but many of the burrows that we excavated burrows had either no pile of soil or a flattened pile less than 50 mm high making them difficult to detect from a distance. Those burrows with multiple entrances and associated mounds of soil to about 250 mm high were obviously easier to detect. Most of these were located adjacent to a clump of spinifex, some of which had been burnt. The pile of soil around the entrance provided no indication of the size, complexity or depth of the burrow that was underground. Given that the size of the mounds at the entrances to most burrows did not reflect the quantity of soil removed to dig the burrow, we concluded that most burrows had been there for a long time and the original mound of soil had been dispersed.

Woolley (1990) reported pop holes leading from a vertical shaft from Mulgara burrows; however, we found no burrows with this type of configuration. We have excavated many other burrows in the railway line corridor with vertical pop holes that were devoid of surrounding soil and never found a Mulgara but have occasionally found *Notomys alexis* (Thompson & Thompson 2007).

Our trapping effort (750 Elliott trap-nights) applied over an area of about 22 ha would normally be considered reasonably intensive, given the size of Mulgara's activity area. However, only four of the nine Mulgara captured were caught in traps. This has significant implications for other Mulgara trapping programs as they do not seem to be readily caught in baited Elliott traps. This study was part of a conservation significant fauna assessment and translocation program and had we relied solely on traps to capture all of the Mulgara in the area, then we would have either missed some and they would have died during the clearing process or, alternatively, the trapping program should have lasted for an extended period. These data demonstrate that digging out recently active burrows will reduce the time required to capture all of the Mulgara in an area. Further, digging out burrows in conjunction with trapping is likely to ensure that a greater proportion of the animals in the area are captured than if only traps were used. As the burning of the spinifex made it appreciably easier to locate all of the active burrows, we would recommend that a similar strategy be considered at other sites before a trapping and digging out of burrows program is undertaken to translocate Mulgara out of an area. We appreciate that this may not be possible for other sites, and we would urge that other impacts associated with burning the vegetation should be considered. However, when the area is to be cleared (by bulldozer) of vegetation immediately after all the Mulgara had been relocated any impacts that the fire might have had on the vegetation or other fauna will have been nullified.

As we only searched immediately outside of the area to be cleared and not more widely, we are unsure about the abundance of recently active burrows in the adjacent area, but in the area searched, the density of Mulgara was about one per 2.5 ha and the ratio of Mulgara to recently active burrows was about 1:7. Some of the burrows recorded as active by the marks around the entrance contained reptiles, so we may have over estimated the number of active Mulgara burrows. However, this number is low, with a maximum of five of the sixty five burrows in this category. This would reduce the ratio to 1:6.6. Most of the other areas searched in June 2006 along the railway corridor near the study site did not record high numbers of recently active and inactive burrows, so we concluded that this was a 'hot-spot' for Mulgara and this was the reason for the concerted effort to translocate individuals from this area before it was cleared.

It was apparent that if there were only nine Mulgara in the area and we located 60–65 recently active burrows, then *D. cristicauda* were utilising multiple burrows, probably each evening, which concurs with the findings of Masters (2003). Masters (2003) reported that it was rare to find two adults in the same burrow unless it was the breeding season. The largest two Mulgara that we caught were in the same burrow and the others were all caught by themselves.

Most burrow entrances were similar in size and shape suggesting that they had been initially dug out by Mulgara, but there were a few where the entrance looked very similar to the entrance of a *V. gouldii* burrow, suggesting that it was either initially dug out by a sand goanna or at some stage had been modified by a *V. gouldii*. The internal dimensions of the burrow tunnels were mostly uniform, with larger areas (perhaps nest sites) occurring at the junction of tunnels. The narrowest tunnel was about 40 mm wide, but most were 60–70 mm wide.

Although the horizontal layout of Mulgara burrows varied appreciably (see Figures 4–6), burrows were mostly of a uniform depth between 150 and 300 mm below the true ground surface level, but deeper if measured from the top of the mound of soil around the burrow entrances. This is a little less than the 400 mm reported for the burrow that Masters (2003) excavated in the Tanami Desert. For most burrows there was a single level, with only two burrows having tunnels on two levels. Mounds associated with burrow entrances near clumps of spinifex were often higher than those out in the open, which suggested that once the vegetation was removed, erosive forces were spreading the diggings from burrows over a larger area. Neither the orientation, location of burrow entrances nor tunnel configuration appeared to form a pattern, but the shafts down from the entrance for all burrows were gently sloping.

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