Survey of the underground signs of marsupial moles in the WA Great Victoria Desert

Report to Tropicana Joint Venture and the Department of Natural Resources, Environment and the Arts, Northern Territory Government

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Contents

Summary

- Itjaritjari (Southern Marsupial Mole *Notoryctes typhlops)* and its close relative the Kakarratul (Northern Marsupial Mole *N. caurinus*) from north-western Australia, are little known subterranean animals that inhabit the vast sandy deserts of Central Australia. Elusive, enigmatic, and the sole representatives of a unique and ancient lineage, these animals are rarely encountered and both species are listed as Endangered nationally.
- Although the Great Victoria Desert (GVD) is a major stronghold for Itjaritjari, there are few records of the species from the Western Australia side of the desert. The distribution, abundance and trends of the species in the WA GVD are uncertain.
- The current study was undertaken to provide new information on the distribution and abundance of Itjaritjari in the WA GVD in order to assess the conservation status of the species across this land system.
- Between the 28th April and 14th May 2008, we surveyed a broad range of potential habitats in the WA GVD using trench survey techniques to assess the abundance of Itjaritjari signs underground. The survey sampled a small but representative proportion of the potential Itjaritjari habitat within the WA GVD landscape
- Thirty five sites were sampled at which a total of 89 trenches were excavated. Over 170 backfilled tunnels were recorded in these trenches and at least 95% of these tunnels were considered to have been made by Itjaritjari.
- Moleholes were typically 40 mm in diameter (standard deviation: +/- 3mm) and were similar in every way to those previously measured in the Anangu-Pitjantjatjara-Yankunytjatjara Lands in South Australia (SA) where the identity of backfilled tunnels of about 40mm has been linked to Itjaritjari tracks on the surface, and with the tunnels made by Itjaritjari that were captured and later released.
- The results of the survey indicate that the species still occurs in the WA GVD and that it is widespread and probably more common than previous records suggest. Molehole abundance was similar to that recorded in the SA GVD and suggested that more than 30 km of recognisable moleholes per hectare occurs on the crests and slopes of these dunefields. However, we were unable to estimate the population size as the rates of decay and creation of moleholes is still uncertain. Studies are underway to estimate these quantities; however results are still several years away.
- About 10% of moleholes we recorded appeared fresh, indicating that that Itjaritjari have created an average of about 3 km of backfilled tunnel per hectare since the last soaking rains at the 27 sites at which moleholes were identified in this study.
- We also found that the abundance of moleholes in trenches was strongly related to the hardness of the sand, the height of dunes, the position of a trench on a dune, and the degree of connectivity between dunes.

- The sensitivity of Itjaritjari to the connectivity between dunes suggests that the species may be especially vulnerable to any changes in the configuration and connectivity of dunes that result in patches of dunes being cut off and isolated from the surrounding dunefield matrix. Thus, earthworks that disrupt dune connectivity and effectively fragment Itjaritjari populations could cause more damage to Itjaritjari than the footprint of earthworks might suggest. It would be prudent for earthworks to proceed only with careful consideration of their likely effects on the continuity of Itjaritjari populations, and in conjunction with strategic survey and monitoring of Itjaritjari populations in the area.

Introduction

Marsupial moles (*Notoryctes typhlops* and *N. caurinus*) are little known subterranean animals that inhabit the vast sandy deserts of Central Australia. Elusive, enigmatic, and the sole representatives of a unique and ancient lineage, these species are rarely encountered and are listed as Endangered nationally, although even this is uncertain due to the paucity of information available about their population trends and ecology (Benshemesh 2004).

Direct examination of marsupial mole ecology is virtually impossible with current techniques due to the apparent rarity of the animals and their cryptic subterranean habits, and conventional trapping methods such as the use of Elliot traps or pitfall traps are ineffective for detecting the presence of this species. However, recent studies in the Anangu-Pitjantjatjara-Yankunytjatjara Lands (APYL) have shown that indirect methods provide a means for examining the distribution and abundance of marsupial moles (Benshemesh 2005a). These methods include searching for the underground signs of marsupial moles which provides information on distribution and an index of abundance, and collecting and examining predator scats that occasionally contain marsupial moles remains and DNA and thus provides information on which species occurs in an area. Given that both species of marsupial moles are currently listed as Endangered under the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*, data on the distribution and abundance is urgently needed both to assess the current status of the species, and to provide benchmarks for subsequent monitoring.

The Great Victoria Desert (GVD) straddles the Western Australia (WA) and South Australia (SA) border and is the largest sand dune desert in Australia totalling nearly 40 million hectares. The WA side of the GVD comprises over 20 million hectares and is characterized by vast sand dune habitat that extends from the Nullarbor Plain in the south to the Central Ranges and Gibson Desert in the north (Figure 1). The region stretches from Laverton in the west to the South Australian border in the east, and most of this vast expanse is dunefield habitat.

Itjaritjari (Southern Marsupial Mole *N. typhlops*) have been collected or observed a number of times in the GVD and there are 52 records from this bioregion (including immediate surrounding areas) in museums and wildlife atlases around Australia (Benshemesh 2004). However, most (90%) Itjaritjari records are from the SA side of the desert which supports a larger Aboriginal population and may have received more attention from museum collectors and biological surveys. In any case, only five specimens of marsupial mole have been recorded from the WA GVD and all but one of these were from the vicinity of Warburton and, strictly speaking, occurred in the neighbouring Gibson Desert and Central Ranges bioregions. The only other specimen of marsupial mole collected in or near the WA GVD was recorded from Queen Victoria Springs in 1996 (Pearson and Turner 2000). While one of the specimens from the vicinity of Warburton is thought to be *N. caurinus*, all the other specimens from the GVD including those from SA, Queen Victoria Springs, and most of those from near Warburton have been confirmed to be Itjaritjari (*N. typhlops*) by morphological and/or genetic analysis (Benshemesh 2004). It is thus very likely that *N. typhlops* occurs throughout the WA GVD, while *N. caurinus* may occur as well in the far north near the Gibson Desert.

While Itjaritjari specimens and sightings are poorly represented in the WA GVD, Burbidge et al (1988) nonetheless found that Aboriginal traditional owners in the 1980s were familiar with the animal and believed that they still occurred within what are now known as the Neale Junction and Great Victoria Desert Nature Reserves, and in the country in between. Aboriginal people from the region also recalled Itjaritjari within living memory in the Central Ranges bioregion north west of Warburton, and in the south east corner of the Gibson Desert bioregion adjoining the WA GVD. Trenches excavated opportunistically to search for Itjaritjari at various locations in the WA GVD in the late 1990s also suggested that the species may be widespread in the WA GVD (Martin Schulz; pers. comm. 1999).

Within this context of very limited knowledge of the distribution and abundance of Itjaritjari in the WA GVD, we attempted to survey a broad sweep of this vast landscape in a short period of time using trench survey techniques to assess the abundance of Itjaritjari underground. In this report, we present and analyse these data by:

- comparing underground features we recorded in the WA GVD with those obtained previously in the APYL where Itjaritjari are known to occur and where the trenching techniques were developed (J Benshemesh in prep.);
- examining the abundance of Itjaritjari signs in relation to a range of environmental features; and
- considering the conservation status and threats to Itjaritjari in regard to the data collected.

The survey occurred between 28th April and 14th May 2008 and was greatly enhanced in the field by the assistance by members of Ngaanyatjarra Land Management while on Ngaanyatjarra and Cosmo Newbury Aboriginal Land. We are especially thankful to Alex Knight, Gordon Sanders, Reggie Smith, Mark Butler, Jo Miller, Joyce Nelson, Kirk Bennan, Peter Twigg, Belinda Bastow (AngloGold Ashanti Australia – AGAA) and collectively to the people of Ngaanyatjarra, Cosmo Newbury, Pila Ngura, Maralinga Tjarutja (SA) and Wongatha for allowing us to undertake the survey on their land. Bretan Clifford (Dept. Of Natural Resources, Environment the Arts and Sport (NRETA, NT) prepared the sand dune maps. The study was conducted under WA Dept. of Environment and Conservation (DEC) and SA Dept. of Environment and Heritage (DEH) scientific permits and funded by Tropicana Joint Venture and Natural Heritage Trust, NRETA (NT).

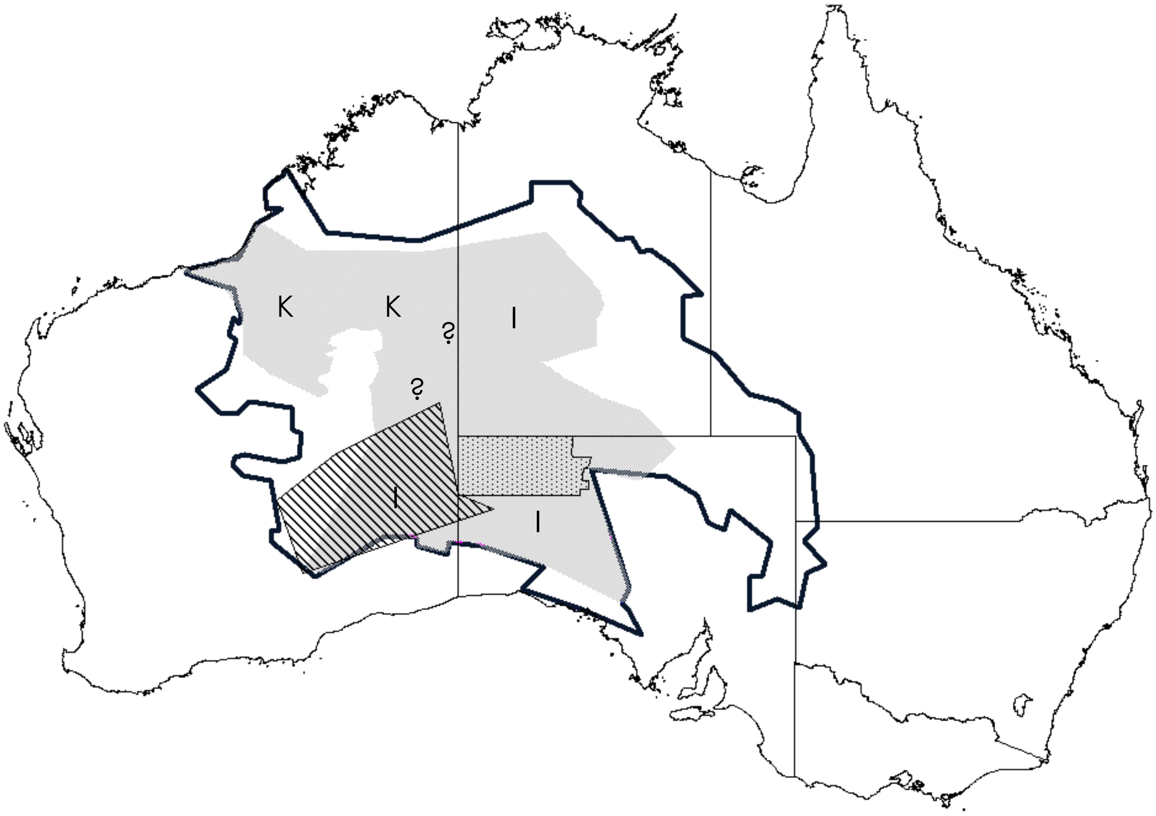


Figure 1. Locality map showing the maximum likely range of marsupial moles (thick black line;), and the minimum likely range (solid grey polygon) (modified from Benshemesh 2004). Within these areas, the Kakarratul occurs in the north west of WA and the Itjaritjari elsewhere ('K 'and 'I' respectively) although the exact boundaries are uncertain (indicated by '?') and either or both species may occur there. The area sampled in the current study (cross hatched) and the APYL (stippled) are also shown.

Methods

Sites

Sites were selected to broadly sample the deep sandy desert that forms the majority of the WA GVD. A total of 35 sites were sampled and all sites were close (usually 100 to 300m) to vehicle tracks. Sampling sites and the route travelled are shown in Figure 2.

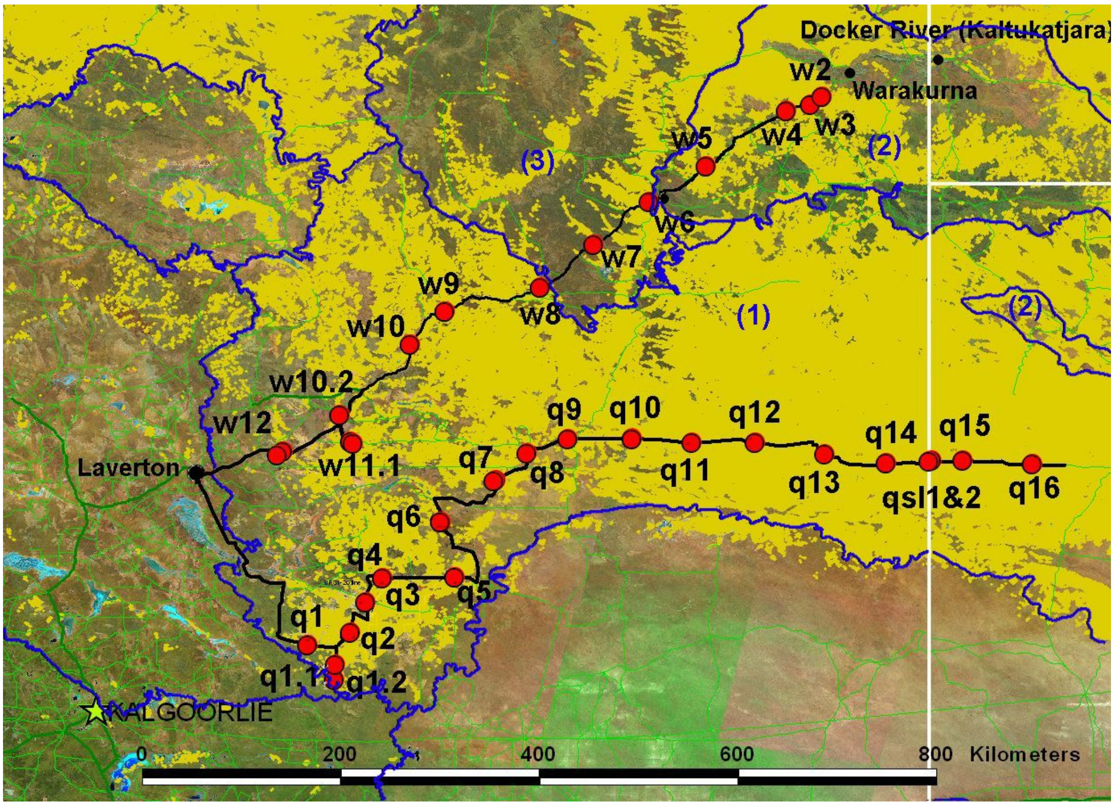


Figure 2. Map showing route (black line) and sites (red circles) of marsupial mole survey. The yellowish-brown areas show the extent of dunes in the WA GVD. Bioregion boundaries are also shown (blue lines). Bioregions mentioned in the text are indicated by bracketed numbers: 1) Great Victoria Desert Bioregion; 2) Central Ranges Bioregion; and 3) Gibson Desert Bioregion.

Most sites represented dunes, although a few sites were selected on gentle sandy rises as dunes were not present. At each site, a series of three trenches was usually excavated, although the number of trenches varied from 2-4 depending on the amount of time available. These trenches generally sampled the upper, mid and base of the dune, and were located on the north side of the dune to maximise exposure to the sun. Upper dune sites were within 10m of crest, whereas the base of the dune was regarded as where the slope became flat. Mid sites were located about half way down between upper and base sites. At some locations not all trenches were excavated due to lack of time, and in these cases priority was always given to upper and midslope trenches as previous experience in the GVD had shown that trenches at the base of dunes generally contained fewer signs of marsupial mole than those at more elevated parts of dunes (J Benshemesh, Unpublished).

The precise location of each trench was influenced by existing vegetation and trenches were placed away from trees and large shrubs so that few large roots needed to be severed. Avoiding large roots made working in the trenches easier and minimised damage to surrounding vegetation. Only one series of trenches was dug at each dune, the objective being to maximise the coverage of the survey rather than to provide detailed information on marsupial mole abundance at each site.

Trenches

Trenches were excavated to be at least 100 cm long by 80cm deep and 30-40cm wide. The long axis of each trench was aligned east-west to maximise sunshine on the north face of the trench wall (for further description and diagrams, see Benshemesh 2005a). This was the only trench face that was inspected for marsupial mole signs and we carefully rubbed this face to present a flat and smooth surface. The top of the opposite wall was also dug out to maximise sunshine on the north face. Branches were placed in each trench and arranged as an escape route for any animals that accidentally fell into the trench.

Moleholes

Each site was visited twice, first to excavate the trenches and then again a varying number of days later in order to obtain a final reading of the number of marsupial mole backfilled tunnels (henceforth "moleholes"). A rough initial count of moleholes was recorded shortly after the trenches were excavated in case rain or other conditions made later readings impossible. Final readings of trenches occurred one to fifteen days after they were excavated during which time conditions were dry and daily maximum temperatures were usually between 25 and 30°C. To detect moleholes during the final readings, we gently rubbed the surface of the north facing trench wall until it was smooth and flat once again and then lightly threw handfuls of dry sand onto the wall. This process gently erodes the surface and tends to make the edges of moleholes more apparent as the backfilled passage erodes more than the surrounding sand. All oval and symmetrical sand filled structures with a minimum dimension greater than 20 mm were measured in regard to their depth, minimum and maximum dimensions, and the angle of their long axis from vertical (measured with a plumb). In addition, each structure was scored from 1 (low) to 3 (high) in regard to its clarity, and how confident the observer was that the structure was from a marsupial mole. Structures were also rated for how fresh they appeared with scores ranging from 1 (very old) to 5 (fresh and with free flowing sand in the tunnel). All measures of moleholes and trenches were made by the same person (JB) in order to facilitate consistency and comparability with datasets collected in the SA GVD (most of which were also measured by JB)

Additional data

At each trench, the surrounding vegetation was briefly described, cover values were subjectively scored for *Triodia* spp. ('spinifex') and woody vegetation (over 1m), and the habitat was photographed facing along the dune with the trench in the foreground (Figure 3). These photographs are not reproduced here, but are available for reference. Within each trench, we described any anomalies in soil structure and obtained sand samples from 10 cm, 25 cm, and 50 cm depths. These sand samples were collected to provide information on chemical composition and particle size distribution, but have not yet been analysed.

Soil hardness was measured with a pocket penetrometer ("Geotester", Facchini, Italy, with 1 cm shoe). We obtained three penetrometer readings for each level (10cm, 25cm and 50cm) in each trench. Penetrometer readings were obtained on undisturbed sand that had dried in the sun for at least a few hours. This restriction was necessary to minimize the affects of soil moisture which has a considerable influence on soil hardness, and allowed us to compare different sites regardless of the original water content of the soil. Used in this way, the penetrometer measured the force required to fracture rather than to compress the sand.

Finally, we scored the abundance of roots occurring in trenches. Large (>10mm thick), medium (1-10mm) and fine (<1mm) roots were scored separately for each of three levels (0-15 cm, 15-35 cm, and 35-60 cm from the surface).

Fauna were recorded whenever encountered, and one of us (MS) walked along tracks at each site recording fauna when time was available. Fauna records are presented in Appendix 2.

Figure 3. Examples of photographs taken at each trench. The site is Q1 crest and the photographs are taken along the dune from either side of the trench (being filled in).

Table 1. Information collected at each trench locality. See text for further details.

Subject	Variable	Description
Trench	Location	Lat/Long by GPS
Trench	Count of moleholes	Count of backfilled tunnels greater between 20 and 60mm in minimum diameter
Trench	Topography	Crest/midslope/base
Molehole	Dmin	Minimum diameter (mm)
Molehole	Dmax	Maximum diameter (mm)
Molehole	Angle	0-90 degrees (only measured where Dmax was clearly greater than Dmin)
Molehole	Clarity	Scored 1 (very unclear), 2 (clear) or 3 (very clear)
Molehole	Confidence	Scored 1(not confident object is made by Itjaritjari), 2 (confident) or 3 (very confident)
Molehole	Age	Scored 1 (very old) to 5 (fresh with free flowing sand)
Molehole	Depth	Distance from surface to centre of molehole (cm)
Molehole	Hardness In/Out	Penetrometer readings in centre of object and 5cm to side (kr/cm^2)
Trench	Trench dimensions	Length and depth of north facing trench wall inspected for Itjaritjari signs (cm)
Trench	Fire age	Estimated time since the site was last burnt (categorized: 0-1yr, 1-5yr, 6-10yr, 11-20yr, >20yr)
Trench	Soil hardness	Penetrometer readings at 10cm, 25cm and 50cm from surface (3 readings taken at each level)
Trench	Root abundance	Estimated number of large (>10mm thick), medium (1--10mm) and fine (<1mm) roots visible on trench wall in each of three levels (0-15cm, 15-35cm, and 35-60cm)
Trench	Habitat	Plant spp. within 10m
Trench	Gcov (Ground cover)	Estimated ground cover below 1m (%)
Trench	Cover >2m	Estimated cover of shrubs and trees >2m (%)
Trench	Sand colour	Scored 1 (white) to 5 (red)
Trench	Crust	Scored 1 (no surface cryptogamic crust), 2 (mix of crust and loose sand) or 3 (continuous crust).
Trench	Height	Altitude of trench in relation to base of dune, measured with altimeter (metres)
Trench	Photograph	Habitat photos taken facing either way along the dune with trench in foreground
Trench	Sand	About 100g of sand collected from three levels in trench (10cm, 25cm and 50cm)
Trench/ Molehole	Notes	Additional notes on unusual features

Results

Characteristics attributes of backfilled tunnels in WA GVD

Size and shape of backfilled tunnels

The distribution of the minimum dimension of moleholes (Dmin) measured in the WA GVD was very similar to that measured in the Anangu-Pitjantjatjara-Yankunytjatjara Lands (APYL) (Benshemesh, unpublished). Figure 4 shows the Dmin size distribution of all ovoid structures that were measured in these two areas. A bell curve is clearly apparent between the 35-36 mm and 47-48 size classes, and this region of the distribution accounts for 96% and 91% of records from the WA GVD and APYL respectively.

Dmin is an important diagnostic feature of moleholes and is expected to be relatively constant regardless of the structure's age, condition and the angle at which they are intercepted (Benshemesh in prep.). Descriptive statistics of the distributions of molehole-like structures are shown in Table 2, along with statistics for filtered data set in which only likely moleholes are included. Although a slight difference exists between Dmin sizes measured in the WA GVD and APYL, these difference are less than the precision of measurement in the field (1mm) and are not statistically significant (T-test for unequal variances: P>0.05 in both cases).

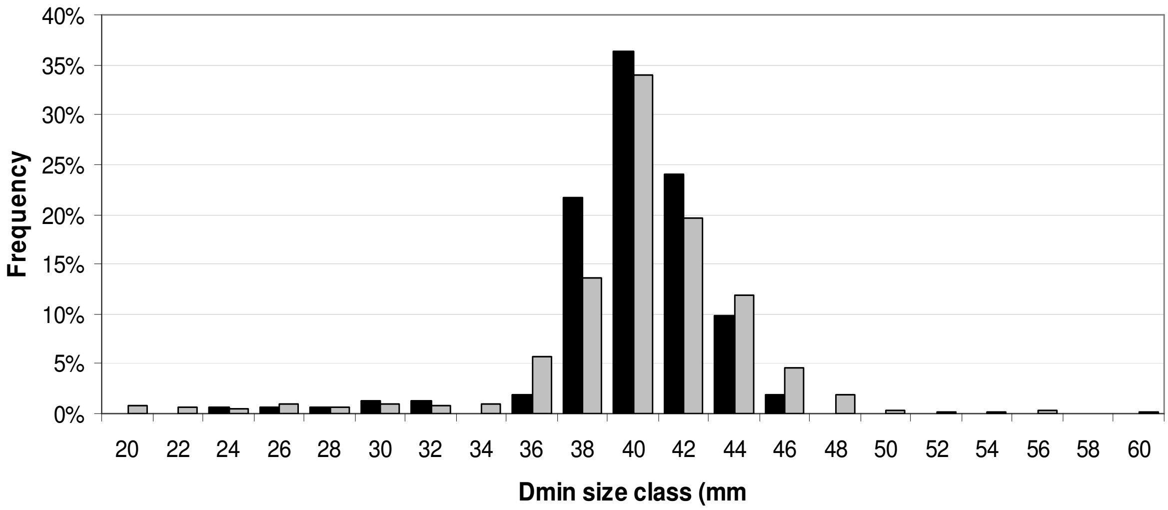


Figure 4. Frequency distribution of the minimum dimension of moleholes in the WA GVD (black bars) compared to those in the Anangu-Pitjantjatjara-Yankunytjatjara Lands (grey bars). Moleholes with a minimum dimension of smaller than 20 mm or greater than 60mm were recorded in the APYL but only rarely (1.3% of records). Sample sizes: n= 162 in WA GVD; n= 1025 in APYL.

Table 2. Statistics of the minimum dimensions of moleholes in the WA GVD compared with those in the APYL in northern GVD. Statistics are shown of both the full data set from each location, and of a filtered data set in which only likely moleholes is included (i.e. records were excluded where Dmin was than less than 34 mm and greater 60 mm, or where observer confidence was low or not recorded).

	All measured structures		Likely Moleholes	
	WA GVD	**APYL**	**WA GVD**	**APYL**
Mean	39.57 mm	39.86 mm	40.05 mm	40.38 mm
St. Error	0.245 mm	0.227 mm	0.158 mm	0.113 mm
Median	40 mm	40 mm	40 mm	40 mm
Mode	40 mm	40 mm	40 mm	40 mm
n	162	1039	150	629
Range	24-46 mm	5-180 mm	36-46 mm	34-55 mm

While the Dmin measure is expected to be relatively insensitive to how tunnels are intercepted, the Dmax measure is determined by both the original size of the tunnel, and the angle at which it is intercepted. Dmax frequency distributions for the WA GVD and the APYL were broadly similar (Figure 5). Likewise the D-ratio variable (ratio of the maximum to minimum diameters of moleholes) was similarly distributed in the WA GVD and APYL (Figure 6).

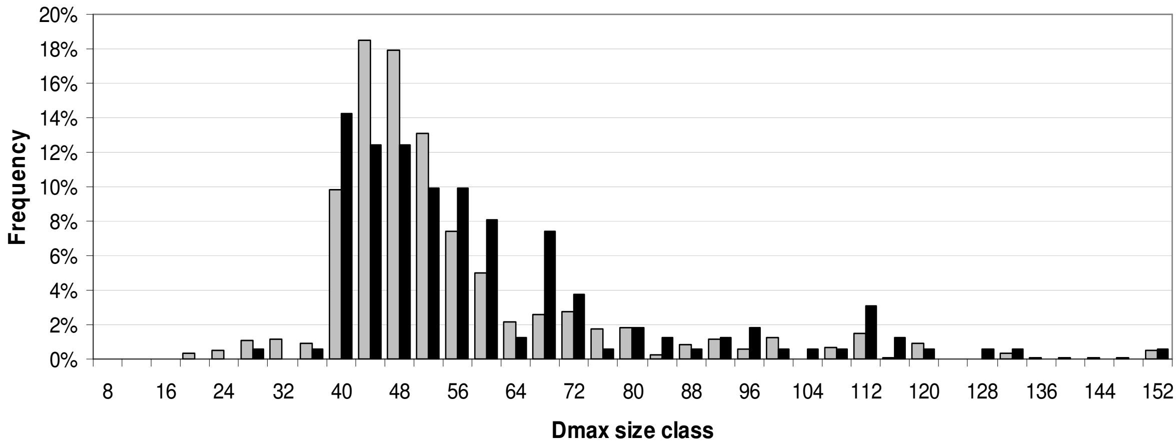


Figure 5. Frequency distribution of the maximum dimension of moleholes in the WA GVD (black bars) compared to those APYL (grey bars). Sample sizes: n= 162 in WA GVD; n= 861 in APYL. Note that APYL sample size differs from that in Table 1 as Dmax was not always measured in the APYL.

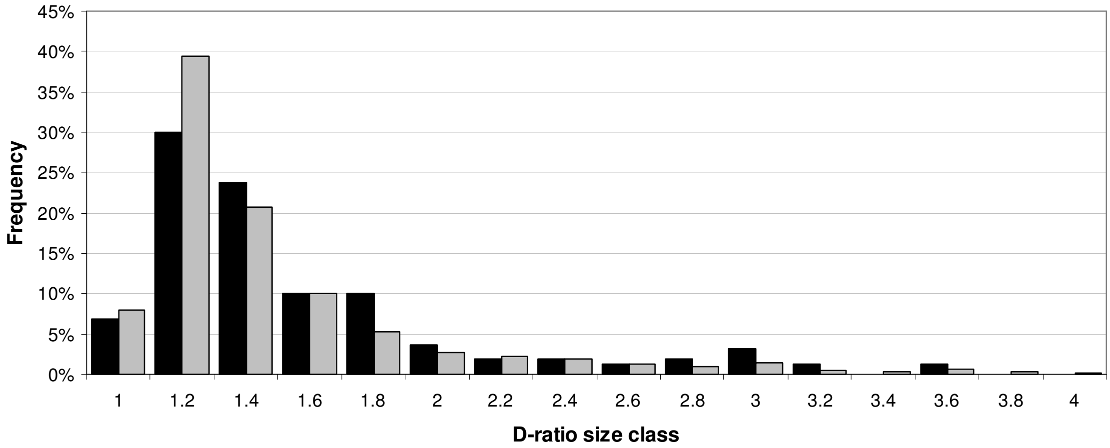


Figure 6. Frequency distribution of the D-ratio moleholes in the WA GVD (black bars) compared to those in the APYL (grey bars). Sample sizes: n= 162 in WA GVD; n= 861 in APYL.

The distribution of the angle (from the vertical) of the long dimension of moleholes measured from the lower GVD (Figure 7) was similar to that measured in the APYL. As in data from the APYL, most moleholes in the WA GVD suggested horizontal rather than vertical movement, with more than half of all measured moleholes having a long axis within 30° of horizontal (61-90° class in Figure 7).

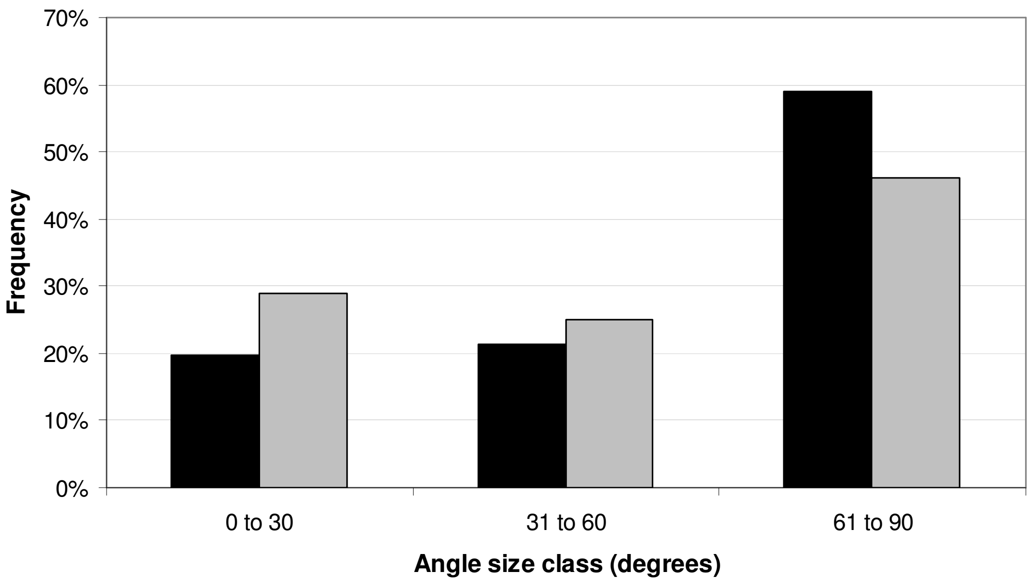


Figure 7. Frequency distribution of the angle (from vertical) of the long dimension of moleholes measured from the WA GVD (black bars) compared to those in the APYL (grey bars). Sample sizes: n= 112 in WA GVD; n= 360 in APYL.

Depth of backfilled tunnels

Molehole depth showed a similar pattern in the WA GVD to that previously recorded in the APYL (Figure 8): moleholes occurred most commonly in the 21-40 cm depth range, were progressively less common away from this band and were least common in the top 10 cm of a trench. However, in the WA GVD, molehole structures were more likely to occur at shallower depths (less than 30cm) than in the APYL.

The depth at which moleholes and other structures occur provides a means of comparing backfilled tunnels measured in the WA GVD with those previously measured in the APYL, and presumably also reflects the ecological preferences of the animals. Descriptive statistics of the distributions of molehole-like structures are shown in Table 3, along with statistics for filtered data set in which only likely moleholes are included. Although the difference between mean depths of likely moleholes is significant (T-test for equal variances: $t=2.76$, $df= 641$, $p<0.01$), the magnitude of the difference is small (less than 4 cm).

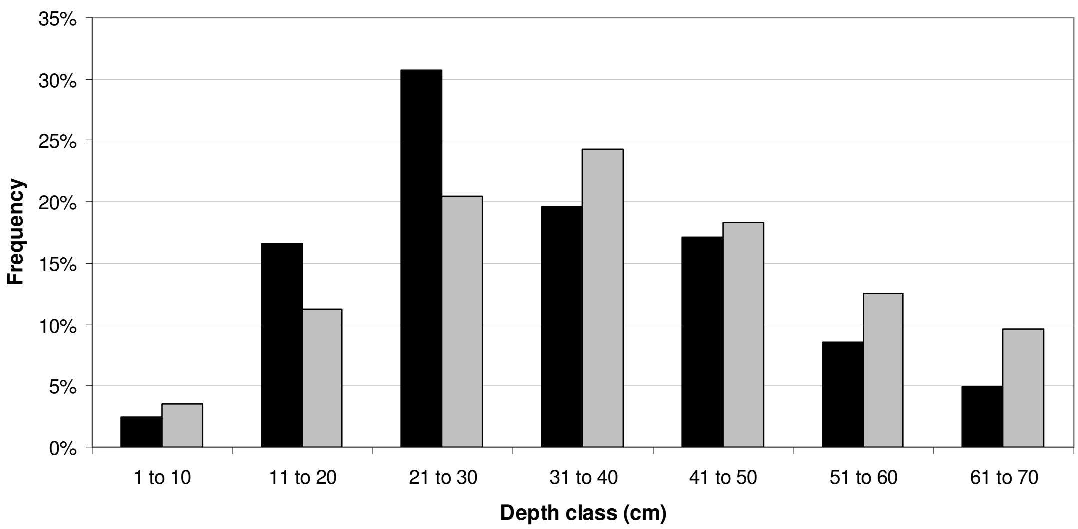


Figure 8. Frequency distributions of molehole depth recorded in the WA GVD (black bars; n=163) and APYL (grey bars; n=1099). To enable comparison across trenches of variable depth, only moleholes within the first 69 cm were included in these frequency distributions.

Table 3. Descriptive statistics of the depth of molehole-like structures in the WA GVD compared with those in the APYL. Statistics are shown of both the full data set from each location, and of a filtered data set in which only likely moleholes are included (ie. records were excluded where Dmin was than less than 34 mm and greater 60 mm, or where observer confidence was low).

	All measured structures		Likely Moleholes	
	WA GVD	**APL**	**WA GVD**	**APL**
Mean	33.49 cm	36.95 cm	32.70 cm	36.67 cm
St. Error	1.123cm	0.46 cm	1.19 cm	0.69 cm
Median	31 cm	36 cm	30 cm	35 cm
Mode	36 mm	30 mm	36 cm	40 cm
n	163	1099	142	501
Range	9-69 mm	4-69 mm	9-69 cm	4-69 cm

Age of backfilled tunnels

Two indices are likely to reflect the age of moleholes: the subjective score for age, and the relative hardness of sand within each backfilled tunnel compared to the surrounding matrix. The first of these, AGE, showed a broadly similar frequency distribution to that recorded in the APYL (Figure 9), although differences were evident between WA GVD and APYL in regard to the frequencies of Oldish and Recent categories. This difference may reflect difficulty in discriminating between Oldish and Recent categories rather than actual differences in moleholes and when combined the Oldish and Recent categories both represented similar frequencies of occurrence (53% of records in WA GVD, 49% in APYL). In any case, mean AGE scores were similar in WA GVD and APYL and there was no significant difference between means for these regions (T-test for equal variances: t=0.02, df=697, P>0.95).

The most important and clearly defined AGE category is Fresh which is characterised by sand flowing freely from moleholes without inducement. Fresh moleholes suggest that the sand has been disturbed while the sand was dry and that there has been no infiltration by water since then; thus fresh tunnels provide evidence of the current occurrence of marsupial moles in an area, whereas the interpretation of other categories is less definitive as molehole decay rate is not known. The frequency of Fresh moleholes in the WA GVD and APYL was similar (10% and 7% respectively), and the difference between these frequencies was not significant (Ch Sq= 1.38, n= 716, P>0.2).

The relative hardness of sand within backfilled tunnels compared to the surrounding matrix also showed similar patterns in the WA GVD and APYL (Figure 10). The frequency of P-ratio values between 0 and 0.1, representing the softest and presumably most recently disturbed sand within tunnels, was almost identical in the two areas. Nonetheless, differences were evident elsewhere in the frequency distributions: P-ratios tended to be lower in the WA GVD (mean= 0.42, se=0.02, n=168) than in the APYL (mean= 0.52, SE= 0.03, n= 158), and this difference was significant (T-test for unequal variances: T= 2.95, df= 289, P<0.01), suggesting that moleholes in the APYL were generally more like the hardness of their surrounding matrix. This difference may be due to different frequencies with which the moleholes had been wetted in the months or years prior to measurement: penetrometer readings from moleholes in the APYL were inspected several years ago during a relatively wet period in central Australia whereas the past four years have been relatively dry.

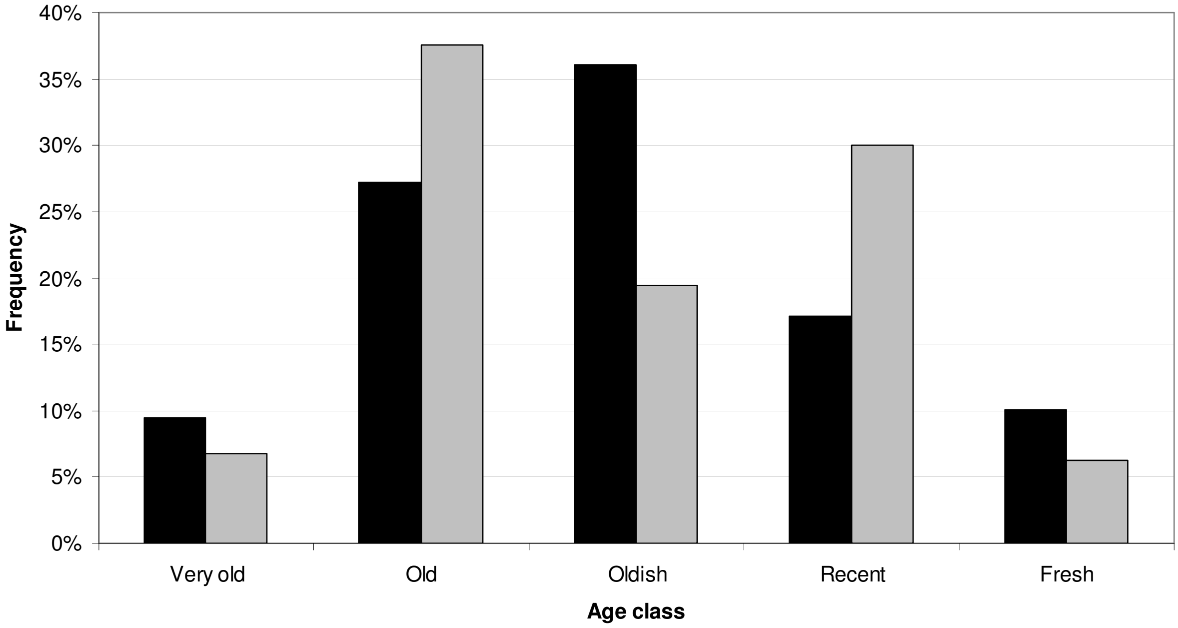


Figure 9. Frequency distributions of molehole AGE scores recorded in the WA GVD (black bars; n=169) and APYL (grey bars; n=530).

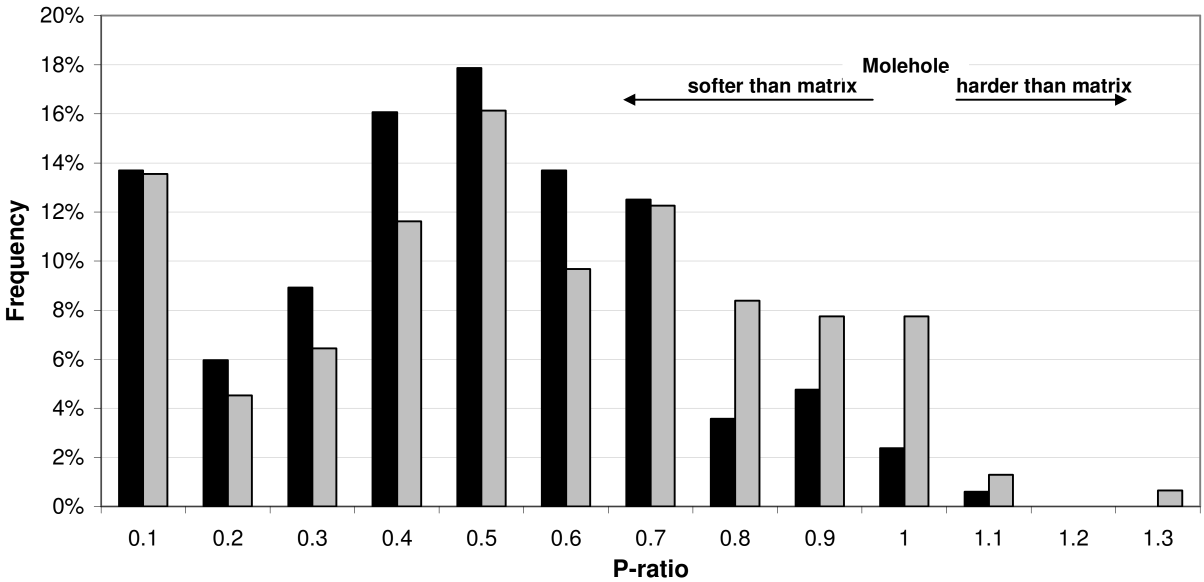


Figure 10. Frequency distributions of molehole P-ratio (penetrometer reading inside the molehole divided by that immediately outside the molehole) recorded in the WA GVD (black bars; n=168) and APYL (grey bars; n=158).

Abundance of moleholes

The vertical density of moleholes (number of moleholes divided by the vertical area of each trench face inspected) provides an index of the relative abundance of marsupial moles in different areas (Figure xxx, Appendix 1) and is used in the following sections to investigate the relationships between the abundance of marsupial moles and environmental variables. Because this index is based on counts of moleholes in similar sized trenches (modified to correct for variation in trench size) and was best described by Poisson distribution, we applied square-root transformations to improve the normality of molehole density estimates in all parametric statistical tests.

Trench drying time

Quick counts of the number of moleholes visible in each trench were obtained immediately after each trench was excavated, and these data indicated that the initial numbers were on average only a third that of the number of moleholes counted after the trenches were dried, and this difference was significant (Paired T-test: $t=-7.7$, $n=82$, $p<0.0001$; initial counts were not obtained at 7 trenches). Nonetheless, the initial and final counts of moleholes were strongly correlated ($r= 0.80$, $df=80$, $p<0.0001$).

These findings highlight the importance of drying time in determining the number of moleholes in each trench. Due to the logistics involved in this study, we were unable to estimate the number of days needed to dry trenches (e.g. see Benshemesh 2005a); nor were we able to visit each trench after a set number of days. Thus, our trenches were exposed for a variable number of days between when they were excavated, and when they were finally examined in detail for moleholes (Figure 11). However, the effect of this variable on the final number of moleholes that we recorded in each trench was slight and there was no evidence of a significant relationship between drying time and moleholes numbers: this was the case whether the analysis included all trenches (Pearson correlation: $r= 0.16$, $df= 87$, $p>0.13$); only trenches at sites where at least some moleholes were detected ($r= 0.18$, $df= 65$, $p>0.13$); and where only the first 5 days of drying were included ($r= 0.10$, $df= 24$, $p>0.63$) which is when the greatest effect of drying time on molehole numbers is expected to occur (Benshemesh 2005a).

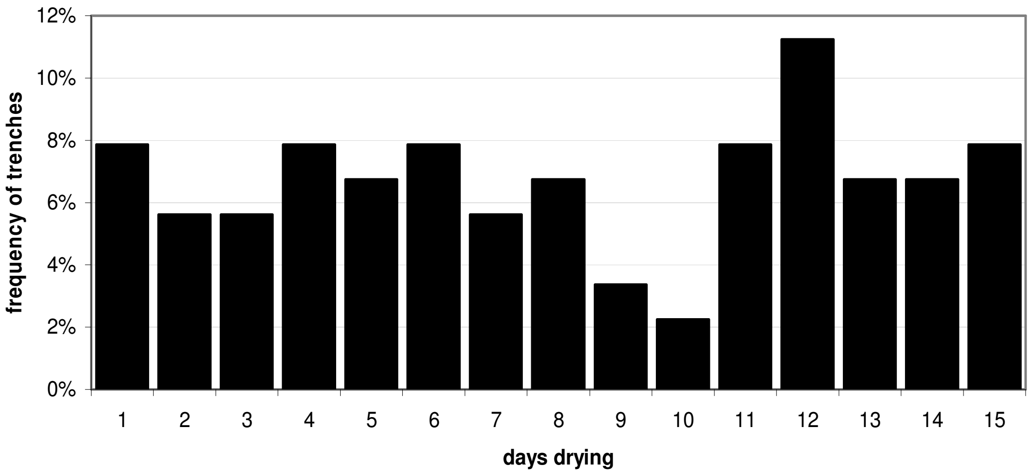


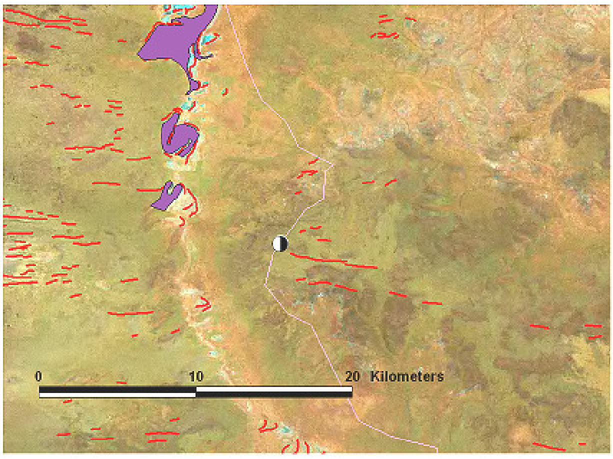
Figure 11. Frequency distributions of the interval of time between excavating trenches in the WA GVD and examining the trenches in detail for moleholes (n=89).

Topography

The number of moleholes in each trench was positively correlated to the height of trenches from the base of each dune, and this relationship was significant ($r=0.31$, $df=83$, $p<0.005$). At sites where at least some moleholes were recorded, differences between the number of moleholes in the three different parts of dunes were not quite significant (ANOVA, $F_{2,61}= 3.10$, df= 63, $p=0.052$), although most moleholes occurred in trenches on the crest and midslope of dunes (mean= 3.7 and 3.0 moleholes m^{-2} respectively), and least in the swales at the base of dunes (mean= 1.5 moleholes m^{-2}). There was also evidence that the height of dunes had an effect on the number of moleholes in trenches on the crest ($r=0.47$, $n=27$, $p<0.02$), but not on the mid slope of dunes ($r= 0.020$, $n=25$, $p>0.9$). There was a negative correlation between the height of dunes and the number of moleholes in the swale but this was not significant ($r= -0.47$, $n=12$, $p>0.10$).

Geography

The geographic connectivity of dunes appeared to have a strong influence on the distribution and abundance of marsupial moles in the WA GVD. To examine this issue, we ranked each of our sites on a scale of 1 (poor connectivity) to 9 (high connectivity) (see Figure 12; Table 4), and averaged the crest and midslope measures of molehole abundance at each site (we omitted swale molehole abundance because these were not measured at all sites). There was a strong correlation between our dune connectivity scores and the molehole abundance at the 35 sites we examined ($r= 0.42$, $df=33$, $P<0.02$). This correlation was largely due to the absence of moleholes at sites that were very poorly connected to surrounding dunefields (score 1 or 2), and there was no correlation evident when these sites were omitted from the analysis ($r=0.04$, $df= 27$, $p>0.8$). There was also a highly significant difference between sites in terms of whether or not moleholes were present at sites that were very poorly connected (score 1 or 2) and those that were connected to some degree (scores 3-9) (Chisq= 19.4, $n=35$, $p<0.0001$).



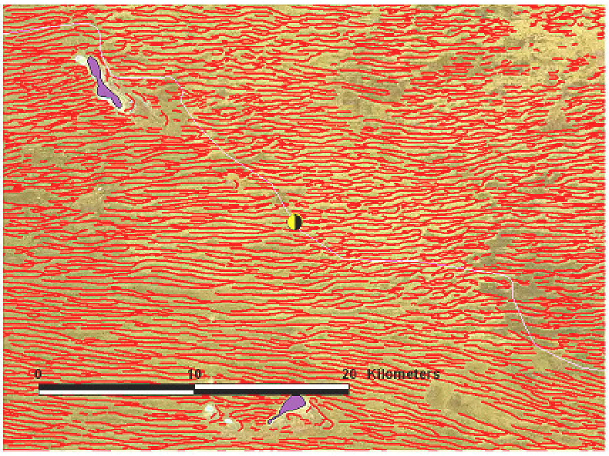


Figure 12. Extremes of dune connectivity shown at marsupial moles trench survey sites in this study. Dunes are highlighted as red lines. On the left is shown an example of a connectivity score=1 (site Q6), and on the right is shown an example of connectivity score= 9 (site Q13).

Table 4. Ranked scores of the degree of connectivity of each site with surrounding dunefields. Scores were assigned by visually assessing the pattern of dunes in the immediate vicinity of each site and also by assessing how well connected these dunes were to dunefields within 20km. Each site was then ranked on a scale from 1 (most poorly connected) to 9 (most well connected).

Connectivity Score	Trench sites									
1	Q6	W12	W12.1							
2	Q7	W10	W10.2							
3	Q7.1									
4	Q1	Q3	Q8	W9						
5	Q1.1	Q1.2	Q2	Q4	Q9	W5	W7	W8	W11	W11.1
6	Q5									
7	Q10	W6								
8	Q11	Qslw	W2	W3	W4					
9	Q12	Q13	Q14	Q15	Q16	Qsl				

Habitat features

The number of moleholes detected per vertical square metre showed a strong negative correlation with the hardness of trenches which was estimated as the average of the nine penetrometer measures at each trench (AvgP). The correlation between the number of moleholes and AvgP was highly significant ($r = 0.48$, $df=87$, $P<0.00001$; Table 5) and accounted for 23% of the variation in these variables. The plot of molehole abundance against AvgP (Figure 13) shows that moleholes only occurred at relatively high densities (>1/m^2) where the average sand hardness of dry wall was 10-30 kg per cm^2, and rarely occurred in trenches with harder substrates. Molehole abundance was also negatively correlated to the occurrence of surface crust (Crust) and the amount of ground cover (Gcov), and positively correlated to the topography code (Topo). Although each of these three correlations were significant, they may in fact be a reflection of the AvgP which was also strongly correlated to Crust, Gcov, and Topo. The number of moleholes in trenches was not significantly correlated to other variables, such as sand colour (Sand), time since last fire (FireAge), or to the abundance of roots in trenches (Table 5).

Apart from correlations between molehole abundance and habitat features, there were several interesting correlations between habitat features (Table 5). For example, sand colour (coded from yellow=1 to red=5) was significantly correlated to several features, with redder sand associated with more ground cover (Gcov), fewer roots and greater sand hardness. Crustiness of the sand surface showed a similar pattern of relationships except that crust was also highly correlated to topography (scored swale=1 to crest=3). The time since the habitat was last burnt (FireAge) was highly correlated to the amount of both canopy and ground cover. While canopy cover was associated with more large roots in trenches, ground cover was associated with fewer large and medium roots and harder sand, and tended to be greater at lower positions on dunes. Topography and sand hardness were also strongly correlated, as noted previously.

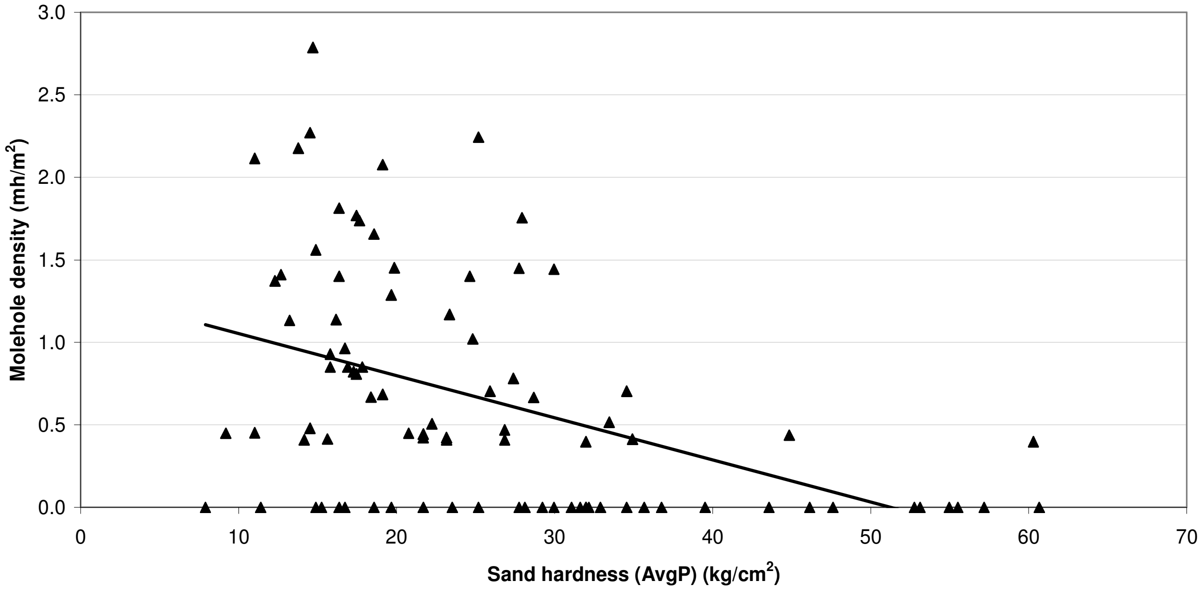


Figure 13. Plot of molehole density against the average hardness (AvgP) of the 89 trenches inspected in the WA GVD trenches.

Table 5. Correlation matrix showing relationships (correlation coefficients, r) between major habitat variables and molehole densities. Molehole densities in each trench were square-root transformed to improve normality, whereas other raw values for other variables have been used. Significance of the correlations is indicated by formatting***:*** *P<0.05*, ***P<0.01***, ***P<0.001*** ; n=89 trenches.

	MHd (Sqrt)	*Sand*	*Crust*	*FireAge*	*Can2*	*Gcov*	*BigRoot*	*MedRoot*	*SmlRoot*	*AvgP*
MHd (sqrt)	1									
Sand	-0.12	1								
Crust	***-0.29***	0.00	1							
Fire_age	-0.08	0.16	0.12	1						
Can2	0.02	-0.09	-0.01	***0.59***	1					
Gcov	*-0.25*	*0.21*	***0.40***	***0.43***	-0.04	1				
BigRoots	0.01	*-0.23*	-0.08	0.13	*0.23*	*-0.22*	1			
MedRoot	-0.03	***-0.33***	*-0.27*	0.06	0.06	*-0.22*	***0.33***	1		
SmlRoot	-0.10	*-0.24*	-0.20	0.08	0.18	-0.02	-0.03	0.10	1	
AvgP	***-0.48***	*0.25*	***0.72***	0.14	-0.05	***0.38***	-0.18	***-0.28***	-0.19	1
Topo	0.23	-0.19	***-0.76***	-0.08	0.16	***-0.47***	0.04	*0.24*	*0.26*	***-0.62***

DISCUSSION

Occurrence of marsupial moles in the WA GVD

In this study we sampled 35 sites at which a total of 89 trenches were excavated and over 170 backfilled tunnels were recorded. Measurements were only collected on structures larger than 20 mm, and we concluded that at least 95% of these were likely to have been made by Itjaritjari. The remaining 5% were of unknown origin but may have been made by insects such as sand gropers (*Cylindracheta* spp.), and conceivably by juvenile Itjaritjari. Moleholes were typically 40 mm in diameter (standard deviation: +/- 3mm) and were similar in every way to those previously measured in the APYL in South Australia where the identity of backfilled tunnels of about 40mm has been linked to Itjaritjari tracks on the surface, and with the tunnels made by Itjaritjari that were captured and later released.

Although records of marsupial moles in the WA GVD are scarce, it is hardly surprising that Itjaritjari is widespread in the GVD as this vast sand-dune desert would seem ideal for the species. Backfilled tunnels have previously been recorded in the WA GVD (M Schulz; pers. comm. 1999), including at Queen Victoria Springs where the recent find of a dead Itjaritjari (Pearson and Turner 2000) has confirmed the current occurrence of the species in the south western GVD. Museum records have also shown the species occurred in the NE between Warburton and the NT border (Benshemesh 2004), and anecdotal information from local Aborigines has indicated that the species also occurred in the heart of the GVD (Burbidge *et al.* 1988).

The current study has filled in some gaps in our knowledge of Itjaritjari in the WA GVD and provided further evidence that the species still occurs in this desert, and is widespread and more common than previous records suggest. In this study, signs of Itjaritjari were encountered in most trenches and at these sites the average abundance of backfilled tunnels was estimated as about three moleholes per vertical square metre on the slopes and crests of dunes. This equates to an average of more than 30 km of recognisable moleholes per hectare in these dunefields, and is similar to molehole abundance in the South Australian GVD (including APYL, Maralinga Tjarutja Lands, and Ooldea areas; J Benshemesh, unpublished data). While this figure may seem surprisingly high, it should be noted that moleholes persist in the sand profile for at least several years and thus accumulate over periods of many years and perhaps many decades.

In this regard, the distributions of age classes, and the measures of the sand hardness inside and outside moleholes, are of particular importance. These data suggest that moleholes appeared of similar age, and were of similar hardness, in the APYL and the WAGVD. Itjaritjari tracks have been observed in the APYL a number of times in recent years, and several animals have been captured, confirming that the species still occurs there and suggesting that Itjaritjari is more common than previously supposed. Given the similarity in age classes and molehole hardness indices, it seems reasonable to suppose that this is also true in the WA GVD.

While the time scale involved in the decay of moleholes is unclear, moleholes in which the sand flowed freely without provocation when they were exposed

('Fresh' age class, and moleholes with 0 hardness measured with a penetrometer) are more easily interpreted and provide reason for some optimism for the conservation of Itjaritjari. The primary cause of re-cementation of sand in dunefields is water infiltration from rain, and Fresh moleholes suggest that they were excavated by Itjaritjari since the last soaking rain and suggests that marsupial moles currently occur at many sites. Indeed, as about 10% of moleholes were regarded as Fresh, these data further suggest that marsupial moles have created an average of more than 3 km of backfilled tunnel per hectare since the last soaking rains at the 27 sites at which moleholes were identified in this study.

Undersized moleholes

While it is tempting to suggest that unusually small moleholes recorded in this study may be made by undersized and perhaps juvenile Itjaritjari, there was no clear evidence of this. In fact, recent studies in the Ooldea area in South Australia (southern GVD) have shown that there was no statistical association between undersized tunnels and those of more typical size, making it unlikely that juveniles Itjaritjari were responsible for undersized moleholes (Benshemesh 2005b). The relative rarity of undersized moleholes in the WA GVD mirrors results from other areas and is probably due to habits of young rather than their abundance: juvenile Itjaritjari probably do not burrow freely through the dunes in the same manner as adults. On the other hand, it is also possible that the rarity of undersized moleholes is due to a lack of recruitment of young Itjaritjari over the past few years or decades. Given these uncertainties, it would be prudent to monitor the abundance of moleholes, especially those that appear fresh, over the following years in case declines are occurring, and to clarify the breeding and rearing habits of these unusual animals.

Marsupial moles distribution and abundance in GVD

Marsupial moles appear to be widely distributed in the WA GVD and their pattern of abundance similar to the SA GVD. In this study we found that the abundance of moleholes in trenches was strongly related to the hardness of the sand, the height of dunes, and the position of a trench on a dune. These three variables are highly correlated and we suspect that they are all related to the composition of the sand: sand at the base of dunes and closer to the swales tends to be much harder as particle size is more heterogeneous and contains more fine material (clay and silt) than higher on the dunes where the action of the wind during dune formation has effectively sorted sands. We are investigating this hypothesis using the 260 sand samples collected during our WA GVD survey, although these analyses are still underway and results are not yet forthcoming.

Another important trend in the abundance of moleholes in trenches concerned the connectivity of dunes to surrounding dunefields. Moleholes were not evident on the most isolated dunes in our study, whereas dunes that were better connected to surrounding dunefields (connectivity scores 3 to 10) tended to have moleholes. There was, however, no evidence that greater connectivity influenced molehole numbers beyond a certain threshold. The findings are consistent with those from other parts of the GVD and from other deserts (J Benshemesh, unpublished data). The sensitivity of marsupial moles to the connectivity of dunefields in the WA GVD suggests that the species requires dunes to disperse and colonise new habitat, and perhaps also that small, isolated populations are untenable in the long term. This sensitivity may also make marsupial moles vulnerable to any changes in the configuration and connectivity of dunes that result in small patches of dunes being cut off and isolated from the surrounding dunefield matrix.

Given the importance of dune connectivity to marsupial moles occurrence, it is interesting that there appears to be little connectivity between dunefields south of Lake Raison and the main body of dunefields in the rest of the GVD. This apparent disjunction is important as, over most of its considerable extent, the GVD is a continuous dunefield in which it is possible to travel widely while always being within 500m of a dune crest (J Benshemesh, unpublished data). However, this is not the case in the south-west of the WA GVD where a minor disjunction occurs south east of Lake Yeo separating the dunefields between Lake Yeo and Lake Raison from the main body of sand in the GVD by 1-2km. More significantly, a major disjunction in the continuity of dunes of at least 4km occurs in the area between Lake Raison and Hope Campbell Lake which apparently separates the dunefields south of Lake Raison from those to the north. In this study, signs of Itjaritjari were identified in each of these areas, and a specimen of Itjaritjari has previously been collected as far south as Queen Victoria Springs (Pearson and Turner 2000, Pearson and Benshemesh 2003), but the occurrence of the species on either side of these apparent disjunctions is of interest because it suggests that the populations may be geographically and genetically isolated. Having stated this possibility, it should also be noted that the lack of dune connectivity does not necessarily mean that Itjaritjari are in fact geographically isolated: suitable soil conditions might permit the dispersal of Itjaritjari in the absence of dunes, and this possibility could easily be examined in the field. It is also worth noting that even if Itjaritjari in the dunefields south of Lake Raison were genetically isolated from the northern dunefields, it is unlikely that they are in imminent danger from the deleterious effects of isolation as the area is large (about 1.5 million hectares) and the population is probably not small. We estimate that there is about 14,000 km of dune habitat south of Lake Raison which is potentially available for Itjaritjari, and our study suggests that Itjaritjari occur widely across this area, as does other data commissioned by AGA (Belinda Bastow pers comm.; Stewart Ford pers comm.; Jarad Leigh pers comm.).

The disjunction in dune connectivity north and south of Lake Raison, and the possible isolation of the southern population of Itjaritjari, does however, raise the possibility that the southern population may be susceptible to further fragmentation of their range. Projects involving large scale earth works could, for example, cause more damage to Itjaritjari than their footprint might suggest if their earthworks disrupted dune connectivity and effectively fragmented Itjaritjari populations. In this regard, the area south of Lake Raison has a significant proportion of the available dunefield (about 25% of the dune habitat, or about 3,500 km of dunes) covered by exploration tenure held by a range of companies. Injudicious placement of large scale earthworks in this area could potentially cut linkages that are important to maintaining the integrity of Itjaritjari populations. However, while such fragmentation may threaten Itjaritjari inhabiting these dunefields, adverse effects beyond the footprint of earthworks may be reduced by limiting the scale of disturbance in important dunefield linkages , or by later rehabilitating linkages that have been severed. Accordingly, it would be prudent for earthworks to proceed only with careful consideration of their likely affects on the continuity of Itjaritjari populations, and in conjunction with strategic survey and monitoring of Itjaritjari populations in the area.

Final comments

This study is part of a larger marsupial moles recovery program that is looking into the distribution, movements, diet, and patterns of abundance of marsupial moles across Australia. These studies are providing crucial insights into the ecology of marsupial moles and are helping to clarify the species' conservation status and issues that are important to managing the extant populations.

Of particular relevance to our molehole surveys are concurrent studies in which we are examining the rate at which moleholes decay underground, and the rate at which moleholes are created. These studies involve field monitoring and laboratory simulations of the decay rates of moleholes, and continuous monitoring of geophone grids to estimate the average rate at which Itjaritjari create their backfilled tunnels. These studies will enable us to progress from the current situation in which we are restricted to considering indices of marsupial moles abundance (moleholes), to estimating actual population sizes of marsupial moles in different areas, and under different climatic conditions. Moreover, a more detailed understanding of the creation and decay of moleholes will enable us to determine the appropriate interval between monitoring events and to design efficient monitoring programs.

The results of the current study will be re-examined in the light of these expected developments. We also intend to pool the results described herein with those from other surveys we have undertaken in the GVD and elsewhere in order to enable more complex and powerful analyses. It is for this reason that we have only conducted an exploratory analysis of our results here, rather than attempting more sophisticated multivariate analyses which would enable the influences of many environmental variables to be considered simultaneously and their effects separated. Nonetheless, the exploratory analysis undertaken here should provide clear guidelines to the factors that are likely to be important to marsupial moles, in a form that may be interpreted relatively easily.

It should also be noted that we have not yet analysed all of the data we collected. For example, we collected over 260 sand samples from our trenches and we are still processing these to determine particle size distributions, silt and clay content, soluble salts, and colour, and the influence of these feautures on Itjaritjari distribution and abundance. Likewise, we described the vegetation at each trench site but have not yet looked at the relationships between floristic association and molehole abundance. While we expect our soil measures will provide important insights into the habitat preferences of Itjaritjari, it seems less likely that the species is dependent on particular plant communities given the broad range of Itjaritjari and the distribution of moleholes we have described in the WA GVD and elsewhere.

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Appendix 1

The following table shows the location of trenches we examined and critical details concerning the number of moleholes (MH) in each trench. Trench names are followed by a suffix to indicate their position on dunes: c= crest; m=midslope; s= swale or base; f= flat area. The likely molehole density is the vertical density of structures that were of the appropriate size for Itjaritjari; those of other sizes are of uncertain origin.

Trench name	Date	Days Open	Lat (deg)	Long (deg)	Trench length (cm)	Trench depth (cm)	MH Total	MH Uncertain	Likely MH density (m^{-2-})
q01c	10-5-08	8.1	-30.16522	123.37908	115	75	2	0	2.32
q01m	10-5-08	8.1	-30.16510	123.37923	130	77	1	0	1.00
q01s	10-5-08	8.1	-30.16462	123.37940	140	75	2	0	1.90
q09c	07-5-08	3.9	-28.30230	125.73933	120	72	4	0	4.63
q09m	07-5-08	3.9	-28.30202	125.73933	150	75	2	0	1.78
q10c	07-5-08	3.2	-28.30081	126.31653	110	75	5	0	6.06
q10m	07-5-08	3.2	-28.30068	126.31645	140	75	5	1	3.81
q10s	07-5-08	3.3	-28.30033	126.31645	125	75	1	0	1.07
q11c	07-5-08	3.1	-28.33447	126.86046	110	75	2	0	2.42
q11m	07-5-08	3.1	-28.33420	126.86038	140	75	1	0	0.95
q12c	07-5-08	2.9	-28.33731	127.42979	110	75	8	0	9.70
q12m	07-5-08	2.9	-28.33711	127.42987	135	75	1	0	0.99
q12s	07-5-08	2.9	-28.33628	127.42993	105	72	0	0	0.00
q13c	06-5-08	2.1	-28.44278	128.05803	115	80	1	0	1.09
q13m	06-5-08	2.1	-28.44267	128.05790	140	70	0	0	0.00
q14c	06-5-08	1.9	-28.52513	128.61628	105	76	4	0	5.01
q14m	06-5-08	1.9	-28.52498	128.61618	140	75	2	0	1.90
q14s	06-5-08	1.9	-28.52334	128.61562	140	75	0	0	0.00
q15c	06-5-08	1.0	-28.49735	129.30919	115	85	0	0	0.00
q15m	06-5-08	1.0	-28.49715	129.30918	130	77	0	0	0.00
q16c	05-5-08	0.1	-28.53294	129.93786	120	70	4	0	4.76
q16m	05-5-08	0.1	-28.53279	129.93755	140	75	7	0	6.67
q16s	05-5-08	0.1	-28.53243	129.93750	135	72	3	1	2.06
q1p1c	10-5-08	7.9	-30.47962	123.62324	110	75	2	0	2.42
q1p1m	10-5-08	7.9	-30.47923	123.62355	135	75	1	0	0.99
q1p2c	09-5-08	7.2	-30.34340	123.62849	130	70	1	1	0.00
q1p2m	09-5-08	7.2	-30.34322	123.62849	130	75	1	0	1.03
q2c	09-5-08	7.1	-30.05527	123.77153	100	80	4	1	3.75
q2m	09-5-08	7.1	-30.05511	123.77163	140	75	0	0	0.00
q3c	09-5-08	6.9	-29.77801	123.90386	105	75	1	0	1.27
q3m	09-5-08	6.9	-29.77797	123.90411	110	70	1	0	1.30
q4c	09-5-08	6.8	-29.56009	124.05702	100	70	2	1	1.43

Continued…

Trench name	Date	Days Open	Lat (deg)	Long (deg)	Trench length (cm)	Trench depth (cm)	MH Total	MH Uncertain	Likely MH density (m^{-2})
q4m	09-5-08	6.8	-29.55998	124.05711	145	75	2	1	0.92
q4s	09-5-08	6.8	-29.55965	124.05713	115	70	4	1	3.73
q5c	09-5-08	5.2	-29.55416	124.71004	150	80	0	0	0.00
q5m	09-5-08	5.2	-29.55394	124.71003	150	80	0	0	0.00
q5s	09-5-08	5.2	-29.55361	124.71002	110	70	0	0	0.00
q6f1	08-5-08	5.2	-29.05531	124.58672	100	68	0	0	0.00
q6f2	08-5-08	5.2	-29.05490	124.58596	125	75	0	0	0.00
q6f3	08-5-08	5.1	-29.05230	124.58812	105	60	0	0	0.00
q6f4	08-5-08	5.2	-29.05237	124.58765	120	70	0	0	0.00
q7c	08-5-08	4.9	-28.68709	125.06647	105	60	0	0	0.00
q7m	08-5-08	4.9	-28.68612	125.06620	150	52	0	0	0.00
q7p1c	08-5-08	4.8	-28.67251	125.08029	110	75	2	0	2.42
q7p1m	08-5-08	4.8	-28.67232	125.08035	135	80	4	0	3.70
q8c	08-5-08	4.7	-28.43229	125.36720	120	75	0	0	0.00
q8m	08-5-08	4.7	-28.43209	125.36721	135	75	7	0	6.91
qsl1	06-5-08	1.7	-28.50049	129.02579	120	75	0	0	0.00
qsl2	06-5-08	1.7	-28.50058	129.02545	140	80	2	0	1.79
qslw1	06-5-08	1.7	-28.50657	129.00560	135	75	1	0	0.99
qslw2	06-5-08	0.1	-28.50502	129.00523	150	85	0	0	0.00
w02c	13-5-08	14.2	-25.20452	128.03403	130	80	5	0	4.81
w02m	13-5-08	14.2	-25.20468	128.03418	115	75	1	0	1.16
w02s	13-5-08	14.2	-25.20527	128.03482	120	80	0	0	0.00
w03c	13-5-08	14.1	-25.27851	127.92889	130	70	1	0	1.10
w03m	13-5-08	14.1	-25.27832	127.92900	135	70	8	0	8.47
w04c	13-5-08	14.0	-25.33394	127.71468	115	70	7	1	7.45
w04m	13-5-08	14.0	-25.33377	127.71464	120	70	8	2	7.14
w04s	13-5-08	14.0	-25.33338	127.71444	130	70	6	1	5.49
w05c	12-5-08	13.3	-25.83420	126.98837	110	70	7	0	9.09
w05m	12-5-08	13.3	-25.83392	126.98839	120	75	5	0	5.56
w05s	12-5-08	13.3	-25.83247	126.98860	125	70	0	0	0.00
w06c	12-5-08	13.1	-26.16098	126.47122	105	70	2	0	2.72
w06m	12-5-08	13.1	-26.16074	126.47131	115	80	2	0	2.17
w07c	12-5-08	12.9	-26.54759	125.97250	110	75	11	2	10.91
w07m	12-5-08	12.9	-26.54733	125.97252	110	70	5	1	5.19
w07s	12-5-08	12.9	-26.54648	125.97292	150	70	1	0	0.95
w08c	12-5-08	12.8	-26.93012	125.48702	110	80	2	1	1.14
w08m	12-5-08	12.8	-26.92987	125.48711	120	80	0	0	0.00
w08s	12-5-08	12.8	-26.92961	125.48716	105	70	0	0	0.00

Continued…

Trench name	Date	Days Open	Lat (deg)	Long (deg)	Trench length (cm)	Trench depth (cm)	MH Total	MH Uncertain	Likely MH density (m^{-2})
w09c1	12-5-08	11.9	-27.15314	124.62185	120	70	1	0	1.19
w09c2	12-5-08	11.9	-27.15363	124.62149	125	80	1	1	0.00
w09m	12-5-08	11.9	-27.15297	124.62174	120	70	3	0	3.57
w09s	12-5-08	11.9	-27.15252	124.62171	130	70	0	0	0.00
w10.2c	11-5-08	11.0	-28.08788	123.66884	120	75	0	0	0.00
w10.2m	11-5-08	11.1	-28.08765	123.66880	110	75	0	0	0.00
w10.2s	11-5-08	11.1	-28.08644	123.66859	120	70	0	0	0.00
w10c	11-5-08	11.3	-27.44960	124.30886	130	75	0	0	0.00
w10m	11-5-08	11.3	-27.44946	124.30883	105	60	0	0	0.00
w10s	11-5-08	11.3	-27.44853	124.30861	110	25	0	0	0.00
w11.1c	11-5-08	10.8	-28.34502	123.79565	130	65	3	0	3.55
w11.1m	11-5-08	10.9	-28.34478	123.79558	135	70	4	0	4.23
w11c	11-5-08	10.8	-28.33136	123.77080	120	75	1	0	1.11
w11m	11-5-08	10.8	-28.33116	123.77100	130	75	1	0	1.03
w12c	11-5-08	10.1	-28.41981	123.15572	115	72	0	0	0.00
w12m	11-5-08	10.1	-28.41967	123.15568	135	80	0	0	0.00
w12p1c	11-5-08	9.9	-28.44597	123.11102	115	80	0	0	0.00
w12p1m	11-5-08	10.0	-28.44589	123.11115	135	80	0	0	0.00
w12s	11-5-08	10.0	-28.41913	123.15608	140	70	0	0	0.00

Appendix 2. Incidental fauna records

The following two tables present incidental records of birds, mammals and reptiles recorded at trench sites along our survey path: Table a) between Warakurna and Laverton, and Table b) between Queen Victoria Spring and the South Australian border. Sites locations are provided in Appendix 1. The presence of a species at a site is indicated by "+". Most sites were visited twice several days apart, but no effort was made to sample particular times of day.

Table a)Along Great Central Road from Warakurna to Yamarma area, and from Yamana to Laverton.

Species	Sites:	W2	W3	W4	W5	W6	W7	W8	W9	W10	W10.2	W11	W11.1	W12	W12.1
BIRDS															
Emu *Dromaius novaehollandiae*		-	-	-	-	-	-	-	-	-	-	+	+	+	-
Wedge-tailed Eagle *Aquila audax*		-	-	-	-	-	-	-	-	-	-	-	-	+	-
Australian Hobby *Falco longipennis*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Falcon *Falco berigora*		-	-	+	+	-	-	-	-	-	-	+	+	-	-
Nankeen Kestrel *Falco cenchroides*		+	-	-	-	+	-	+	+	-	-	-	+	-	-
Australian Bustard *Ardeotis australis*		-	-	-	+	-	+	+	+	-	-	-	-	-	-
Little Button-quail *Turnix velox*		-	-	-	-	-	-	-	-	-	-	-	-	+	-
Common Bronzewing *Phaps chalcoptera*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested Pigeon *Ocyphaps lophotes*		-	-	-	-	-	-	-	-	-	-	-	-	-	+
Australian Ringneck *Barnardius zonarius*		-	-	-	-	-	-	-	+	-	-	+	-	+	+
Mulga Parrot *Psephotus varius*		-	-	-	-	-	-	-	+	-	-	-	-	-	-
Scarlet-chested Parrot *Neophema splendida*		-	-	-	-	-	-	+	-	-	-	-	-	+	-
Budgerigar *Melopsittacus undulatus*		-	-	-	-	-	-	+	-	-	-	-	-	-	-
Pallid Cuckoo *Cuculus pallidus*		-	-	+	-	-	-	-	-	-	-	-	-	-	-
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Southern Boobook *Ninox novaeseelandiae*		-	-	-	-	-	-	-	-	+	-	-	-	-	-
Barn Owl *Tyto alba*		-	-	-	+	-	-	-	-	-	-	-	-	-	-
Spotted Nightjar *Eurostopodus argus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Australian Owlet-nightjar *Aegotheles cristatus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rufous Treecreeper *Climacteris rufa*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Splendid Fairy-wren *Malurus splendens*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variegated Fairy-wren *Malurus lamberti*		-	-	-	-	-	-	+	-	-	-	-	-	-	-
White-winged Fairy-wren *Malurus leucopterus*		-	-	-	-	-	+	-	-	-	-	-	-	-	-
Striated Pardalote *Pardalotus striatus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inland Thornbill *Acanthiza apicalis*		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species **Sites:**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W10.2**	**W11**	**W11.1**	**W12**	**W12.1**
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Chestnut-rumped Thornbill *Acanthiza uropygialis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Southern Whiteface *Aphelocephala leucopsis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weebill *Smicrornis brevirostris*	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Red Wattlebird *Anthochaera carunculata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Yellow-throated Miner *Manorina flavigula*	-	+	+	-	-	-	-	-	+	+	+	+	+	+
Singing Honeyeater *Lichenostomus virescens*	+	+	+	+	+	+	+	+	+	-	-	-	-	-
Grey-fronted Honeyeater *Lichenostomus plumulus*	-	-	-	-	-	-	-	-	-	+	+	-	-	+
White-fronted Honeyeater *Phylidonyris albifrons*	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Crimson Chat *Epthianura tricolor*	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Orange Chat *Epthianura aurifrons*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jacky Winter *Microeca fascinans*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-capped Robin *Petroica goodenovii*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hooded Robin *Melanodryas cucullata*	-	-	-	-	+	-	-	+	-	+	-	-	-	-
White-browed Babbler *Pomatostomus superciliosus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested Bellbird *Oreoica gutturalis*	-	-	-	-	-	-	-	+	-	+	-	-	+	-
Rufous Whistler *Pachycephala rufiventris*	-	-	-	-	-	-	+	-	-	+	-	-	-	-
Grey Shrike-thrush *Colluricincla harmonica*	-	-	-	-	-	-	-	+	-	+	-	-	-	-
Willie Wagtail *Rhipidura leucophrys*	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Ground Cuckoo-shrike *Coracina maxima*	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Black-faced Woodswallow *Artamus cinereus*	+	+	+	+	+	+	+	+	-	+	-	+	+	+
Grey Butcherbird *Cracticus torquatus*	-	-	-	-	-	+	-	+	-	-	+	-	-	+
Pied Butcherbird *Cracticus nigrogularis*	-	-	-	-	-	-	-	+	-	+	+	-	+	+
Australian Magpie *Gymnorhina tibicen*	-	+	+	+	-	-	-	+	-	-	-	-	+	-
Torresian Crow *Corvus orru*	-	-	-	-	-	-	+	+	-	-	-	-	-	-
Little Crow *Corvus bennetti*	+	-	-	-	-	-	-	-	-	-	-	-	+	-
Australian Pipit *Anthus australis*	-	-	+	-	+	+	-	-	+	-	-	-	-	+
Zebra Finch *Taeniopygia guttata*	-	-	-	-	+	+	-	-	-	-	-	-	-	+
Mistletoebird *Dicaeum hirundinaceum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-backed Swallow *Cheramoeca leucosternus*	+	+	+	-	-	-	-	+	-	+	-	+	-	-

Species	**Sites:**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W10.2**	**W11**	**W11.1**	**W12**	**W12.1**
MAMMALS															
Short-beaked Echidna *Tachyglossus aculeatus*		-	-	-	-	-	-	-	-	-	+	-	-	-	+
Western Grey Kangaroo *Macropus fuliginosus*		-	-	-	-	-	-	-	-	-	-	+	-	+	+
Red Kangaroo *Macropus rufus*		-	-	-	-	-	-	-	-	+	-	-	-	-	+
Kangaroo sp. (Unidentified from scats/tracks)		-	-	-	-	-	-	-	-	-	+	-	+	-	-
Hopping Mouse *Notomys alexis*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-striped Freetail-bat *Tadarida australis*		-	-	-	-	-	-	-	-	-	-	-	-	+	-
Gould's Wattled Bat *Chalinolobus gouldii*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lesser Long-eared Bat *Nyctophilus geoffroyi*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dingo *Canis lupus dingo*		+	+	+	+	+	+	+	+	-	-	+	+	-	-
Fox *Vulpes vulpes*		+	+	+	+	-	+	+	-	-	-	+	+	+	+
Feral Cat *Felis catus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
One-humped Camel *Camelus dromedarius*		+	+	+	+	+	+	+	+	+	+	+	+	+	+
European Rabbit *Oryctolagus cuniculus*		+	+	+	-	-	-	-	-	-	-	-	-	-	-
REPTILES															
Gecko *Gehyra purpurascens*		-	-	-	+	-	-	-	-	-	-	-	-	-	-
Beaded Gecko *Lucasium damaeum*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pale Knob-tailed Gecko *Nephrurus laevissimus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested Dragon *Ctenophorus cristatus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallee Dragon *Ctenophorus fordi*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Military Dragon *Ctenophorus isolepis*		-	-	-	-	-	-	-	-	-	+	-	+	-	+
Central Netted Dragon *Ctenophorus nuchalis*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Painted Dragon *Ctenophorus pictus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dragon Diporiphora reginae		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thorny Devil *Moloch horridus*		-	-	+	-	-	-	-	+	-	+	-	-	+	-
Pygmy Desert Monitor *Varanus eremius*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pygmy Mulga Monitor *Varanus gilleni*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sand Goanna *Varanus gouldii*		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skink *Ctenotus brooksi*		-	-	+	-	-	-	-	-	-	-	-	-	-	-
Skink *Ctenotus helenae*		-	-	-	-	-	-	-	-	-	+	-	-	-	-
Skink *Ctenotus quattuordecimlineatus*		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	Sites: W2	W3	W4	W5	W6	W7	W8	W9	W10	W10.2	W11	W11.1	W12	W12.1
Skink *Ctenotus schomburgkii*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Narrow-banded Sand-swimmer *Eremiascincus fasciolatus*	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Skink *Lerista bipes*	+	-	-	-	-	-	+	+	-	+	-	-	-	-
Skink *Lerista ips*	-	+	+	-	-	-	-	-	-	-	+	-	-	-
Skink *Menetia greyii*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western Brown Snake *Pseudonaja nuchalis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table b) Great Victoria Desert from Queen Victoria Spring to Ann Beadell Hwy and east to about 100km past South Australian border.

Species	Q1	Q1.1	Q1.2	QSP*	Q2	Q3	Q4	Q5	Q6	Q7	Q7.1	Q8	Q9	Q10	Q11	Q12	Q13	Q14	QSLW	Q15	Q16
BIRDS																					
Emu *Dromaius novaehollandiae*	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Wedge-tailed Eagle *Aquila audax*	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Australian Hobby *Falco longipennis*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Brown Falcon *Falco berigora*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	-	-	-	+
Nankeen Kestrel *Falco cenchroides*	+	+	-	+	-	-	-	-	-	-	+	-	-	-	+	-	-	+	-	-	-
Australian Bustard *Ardeotis australis*	-	+	+	+	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	+	+
Little Button-quail *Turnix velox*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Bronzewing *Phaps chalcoptera*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crested Pigeon *Ocyphaps lophotes*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Australian Ringneck *Barnardius zonarius*	+	+	-	-	-	+	+	+	+	-	-	-	-	+	-	+	-	+	-	+	-
Mulga Parrot *Psephotus varius*	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	+	-	+	+
Scarlet-chested Parrot *Neophema splendida*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Budgerigar *Melopsittacus undulatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-
Pallid Cuckoo *Cuculus pallidus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-
Southern Boobook *Ninox novaeseelandiae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barn Owl *Tyto alba*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spotted Nightjar *Eurostopodus argus*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Australian Owlet-nightjar *Aegotheles cristatus*	+	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-

Species	Q1	Q1.1	Q1.2	QSP*	Q2	Q3	Q4	Q5	Q6	Q7	Q7.1	Q8	Q9	Q10	Q11	Q12	Q13	Q14	QSLW	Q15	Q16
Rufous Treecreeper *Climacteris rufa*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Splendid Fairy-wren *Malurus splendens*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+
Variegated Fairy-wren *Malurus lamberti*	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Fairy-wren *Malurus leucopterus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Striated Pardalote *Pardalotus striatus*	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+
Inland Thornbill *Acanthiza apicalis*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	+
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chestnut-rumped Thornbill *Acanthiza uropygialis*	-	-	+	-	-	-	+	+	+	-	-	-	-	+		-	-	+	+	-	+
Southern Whiteface *Aphelocephala leucopsis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Weebill *Smicrornis brevirostris*	+	-	+	-	+	+	+	+	+	-	-	-	+	-	-	-	+	+	+	-	+
Red Wattlebird *Anthochaera carunculata*	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	-	-	-	+	-	-	-	+	-	-	-	-	+	+	+	+	+	-	+	-	+
Yellow-throated Miner *Manorina flavigula*	+	-	+	-	+	+	+	+	-	-	-	+	+	+	-	+	-	+	-	+	+
Singing Honeyeater *Lichenostomus virescens*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-
Grey-fronted Honeyeater *Lichenostomus plumulus*	-	-	-	+	-	+	+	-	+	-	-	+	+	+	+	+	+	+	+	+	+
White-fronted Honeyeater *Phylidonyris albifrons*	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	+
Crimson Chat *Epthianura tricolor*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
Orange Chat *Epthianura aurifrons*	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Jacky Winter *Microeca fascinans*	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
Red-capped Robin *Petroica goodenovii*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Hooded Robin *Melanodryas cucullata*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
White-browed Babbler *Pomatostomus superciliosus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Crested Bellbird *Oreoica gutturalis*	-	-	-		-	+	+	-	-	-	-	-	+	+	-	+	+	+	+	+	+
Rufous Whistler *Pachycephala rufiventris*	-	-	-	+	-	-	+	-	+	-	-	-	-	+	-	+	-	+	+	+	+
Grey Shrike-thrush *Colluricincla harmonica*	-	-	-	-	-	-	+	-	+	-	-	+	-	-	-	+	+	+	+	+	+
Willie Wagtail *Rhipidura leucophrys*	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	+	-	+	-	+	+
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	-	-	-	-	-	-	+	+	-	-	-	+	-	+	-	+	+	-	-	+	-
Ground Cuckoo-shrike *Coracina maxima*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Black-faced Woodswallow *Artamus cinereus*	-	-	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
Grey Butcherbird *Cracticus torquatus*	+	+	+	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-
Pied Butcherbird *Cracticus nigrogularis*	+	+	-	+	-	-	+	-	+	-	+	+	-	+	-	+	-	-	-	-	-
Australian Magpie *Gymnorhina tibicen*	+	+	-	-	-	-	-	+	-	-	-	+	-	+	+	-	-	-	-	-	-
Torresian Crow *Corvus orru*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

Species	Q1	Q1.1	Q1.2	QSP*	Q2	Q3	Q4	Q5	Q6	Q7	Q7.1	Q8	Q9	Q10	Q11	Q12	Q13	Q14	QSLW	Q15	Q16
Little Crow *Corvus bennetti*	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Australian Pipit *Anthus australis*	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
Zebra Finch *Taeniopygia guttata*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	+	+	-
Mistletoebird *Dicaeum hirundinaceum*	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
White-backed Swallow *Cheramoeca leucosternus*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	+	+
MAMMALS																					
Short-beaked Echidna *Tachyglossus aculeatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Western Grey Kangaroo *Macropus fuliginosus*	+	+	+	-	+	+	+	+	-	-	+	-	-	+	-	+	-	-	-	+	-
Red Kangaroo *Macropus rufus*	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Kangaroo sp. (Unidentified from scats/tracks)	-	-	-	+	-	-	-	-	+	+	-	+	+	-	+	-	-	+	-	-	+
Hopping Mouse *Notomys alexis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-
White-striped Freetail-bat *Tadarida australis*	+	+	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Gould's Wattled Bat *Chalinolobus gouldii*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lesser Long-eared Bat *Nyctophilus geoffroyi*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-
Dingo *Canis lupus dingo*	-	+	+	-	+	-	-	+	-	+	+	+	+	+	+	+	-	-	-	-	+
Fox *Vulpes vulpes*	+	-	+	+	-	-	+	-	+		+	+	+	-	+	+	+	+	+	+	+
Feral Cat *Felis catus*	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-	+	+	-	+
One-humped Camel *Camelus dromedarius*	-	+	+	+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
European Rabbit *Oryctolagus cuniculus*	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REPTILES																					
Gecko *Gehyra purpurascens*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beaded Gecko *Lucasium damaeum*	-	+	+	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-		-
Pale Knob-tailed Gecko *Nephrurus laevissimus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Crested Dragon *Ctenophorus cristatus*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallee Dragon *Ctenophorus fordi*	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Military Dragon *Ctenophorus isolepis*	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	-	+	-	-	+
Central Netted Dragon *Ctenophorus nuchalis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Painted Dragon *Ctenophorus pictus*	-	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-
Dragon Diporiphora reginae	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thorny Devil *Moloch horridus*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
Pygmy Desert Monitor *Varanus eremius*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

Species	Q1	Q1.1	Q1.2	QSP*	Q2	Q3	Q4	Q5	Q6	Q7	Q7.1	Q8	Q9	Q10	Q11	Q12	Q13	Q14	QSLW	Q15	Q16
Pygmy Mulga Monitor *Varanus gilleni*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sand Goanna *Varanus gouldii*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skink *Ctenotus brooksi*	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	+	+	-	-	+	-
Skink *Ctenotus helenae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skink *Ctenotus quattuordecimlineatus*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
Skink *Ctenotus schomburgkii*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Narrow-banded Sand-swimmer *Eremiascincus fasciolatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skink *Lerista bipes*	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
Skink *Lerista ips*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skink *Menetia greyii*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western Brown Snake *Pseudonaja nuchalis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+