VERTEBRATE FAUNA

Andrew A. Burbidge, P.J. Fuller and N.L. McKenzie

Background

The philosophies underlying our approach to this vertebrate survey, the sampling strategy adopted, and the actual methods we employed are described in Biological Surveys Committee of Western Australia (1984).

Ten vertebrate quadrats in the Study Area were sampled during each of three visits: 23 July to 3 August 1979 (winter), 8 to 19 September 1980 (spring) and 3 to 13 March 1981 (late summer). During each visit the quadrats were sampled for mammals, birds, reptiles and amphibians for five days and nights; five quadrats being sampled at each of two camp sites. The quadrats near the Mount Manning Range (MM) were either in the Mount Manning Range Nature Reserve or within an area of Crown land surrounded by the reserve, while the remaining quadrats were on Mount Elvire Station (ME), now owned by CALM and proposed to be declared as Mount Elvire State Forest (CALM 1992). Opportunistic vertebrate observations were also made during short visits on 10 – 12 July 1979, 2 October 1980 and 15 – 17 September 1981.

Specimens representing the array of mammal and reptile species encountered in the Barlee–Menzies Study Area during our survey have been lodged in the Western Australian Museum within the following series of register numbers: M18293, M18301 –18314, M18352, M20400–20402, M20414–20419, M20449–20552, M20466–20469, M20471, M20568, M20691–20814, M20817–20819, M20824, M20839–20843, M20852–20854, M20930–20932, M23963, M41911–41999 and R64735–64824, R73325–73435, R78586–78707. Species nomenclature for mammals, reptiles and amphibians in this report follows that of the Western Australian Museum; species names for birds follow the RAOU (see Blakers *et al.* 1984).

The vertebrate quadrats were positioned to sample the most extensive surface lithologies found in the area. Only the main vegetation types of the most extensive landform units were surveyed for vertebrates (Broad Valleys, Salt Lake Features, Sandplains, Banded Ironstone

Table 2 Faunal survey of the Barlee-Menzies Study Area: vertebrate quadrat codes and lithological units cross referenced to vegetation quadrat codes (as in Table 1 and Appendix 1).

Quadrat Code		Lithological Surface (Barlee 1: 250 000 Sheet, Walker & Blight 1983)
Vertebrate	Vegetation	
MM1	BM16	Qc
MM2	BM6	Aiw
MM3	BM5	Qtc / Aiw
MM4	BM20	Qz
MM5	BM12	Ts
ME6	BM21	Qc
ME7	BM13	Ts
ME8	BM23	Qs / Ts
ME9	BM3	Ag
ME10	BM10	Qg

Table 3 Proportion of the Barlee-Menzies Study Area's known indigenous vertebrate species recorded on quadrats.

Taxonomic group	Number of species	
	Total	On quadrats
Mammals	23	15 (65%)
small ground mammals	9	9 (100%)
Amphibians	6	1 (17%)
Reptiles		
snakes	7	2 (29%)
lizards	52	30 (58%)
Birds		
passerines	73	41 (56%)
non-passerines	63[a]	17 (27%)

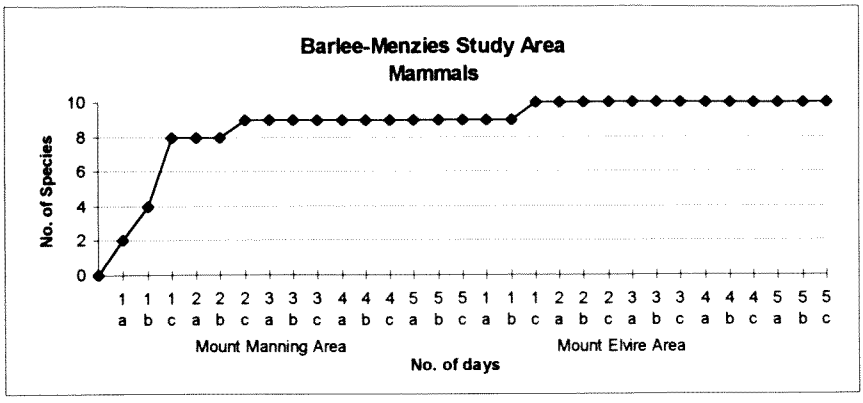
[a] includes 23 waterbirds

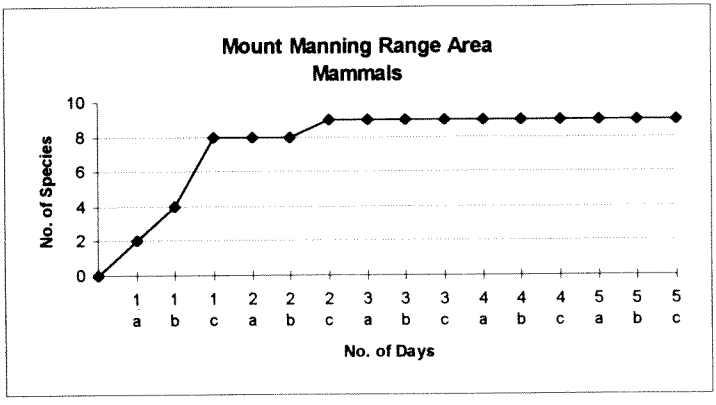
Hills, Undulating Plain and Granite Exposures). This meant that less extensive landforms such as Granite Hills, Greenstone Hills, Breakways and Dunes were not surveyed at all, even though they are prominent in parts of the Study Area.

Table 1 lists the surface lithologies and associated "vegetation types" that are known from the Study Area, while Appendix 1 indicates those that were sampled for vertebrates, cross-references the vertebrate and vegetation sample site codes, and describes the location, vegetation, floristics and substrate of each vertebrate site sampled. We surveyed the vertebrate assemblage from at least one quadrat representing six of the eight major landform units (if the 'Hills' units are combined), eight of more than 30 surface lithologies, and in ten of over 67 vegetation types known in the Study Area (Tables 1 & 2). Much of the floristic diversity of these surface-types was remote from our quadrats. Considering how poorly the vertebrate sampling addressed the environmental heterogeneity of the Study Areas, and how geographically localised our quadrats were (Figure 2), we encountered a surprisingly high proportion of its vertebrates (Table 3).

This coverage was achieved for passerine birds (56%), lizards (58%) and mammals (65%; small ground-dwelling mammals 100%) because most species occurred on a variety of lithologies. For instance, the "average" passerine bird recorded on quadrats occurred in a mean of 2.5 (S.E. = 0.4, n = 40), an "average" lizard in 2.3 (0.3, 29) and an "average" small ground-mammal in 4.7 (0.9, 10), of the ten quadrats sampled (Qtc, Aiw, Qz, Ts, Qc, Qs, Ag and Qg).

Species accumulation curves, in relation to days of effort, were used to investigate whether further sampling effort in the quadrats would have been cost-effective. Previous studies have shown that our broad-scale sampling techniques are unsuitable for certain sorts of species, so they were excluded from the data used to generate the species accumulation curves (Figures 4, 5 & 6) and from subsequent numerical analyses (McKenzie 1984, McKenzie *et al.* 1991a): frogs, snakes, monitors, legless lizards, raptors, owls, water birds, cuckoos, the emu, kangaroos, the echidna, bats and introduced species (except *Mus*). Separate curves were compiled for birds, reptiles and small ground mammals for the Study Area, for the Mount Manning and Mount Elvire survey areas and for each vertebrate quadrat. The accumulation





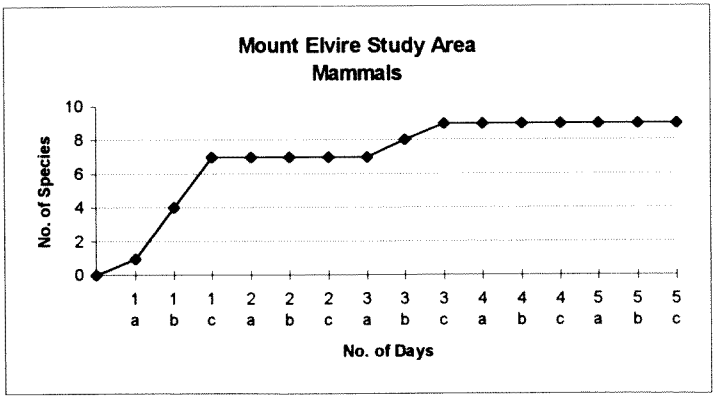
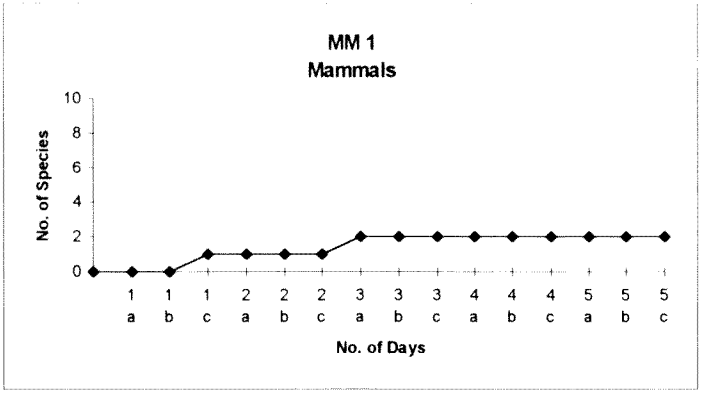
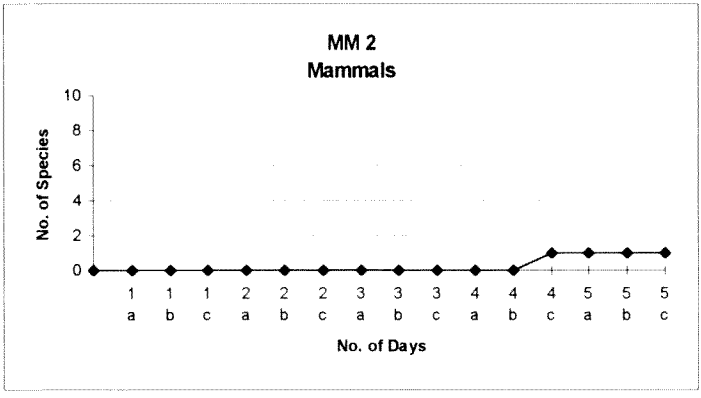


Figure 4 Species accumulation curves for small ground mammals recorded in the total Study Area, at the two Survey Areas and at each quadrat in the Mount Manning (MM1 - 5) and Mount Elvire (ME6 - 10) survey areas. The x-axis is 'days of effort'. The days are ordered from the first day (1) to the fifth day (5) of each sampling session: the winter (a), spring (b) and summer (c) visits.





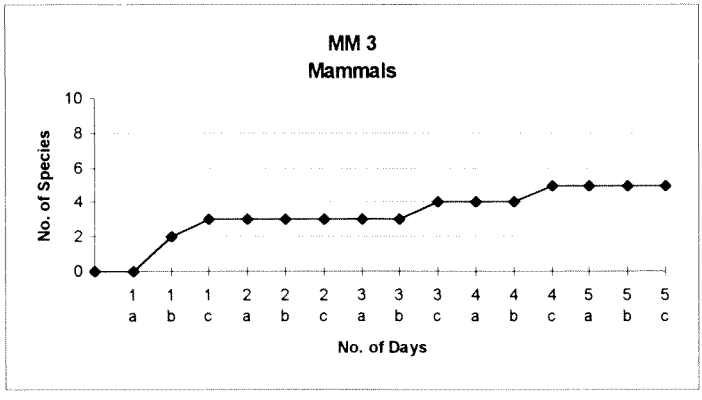
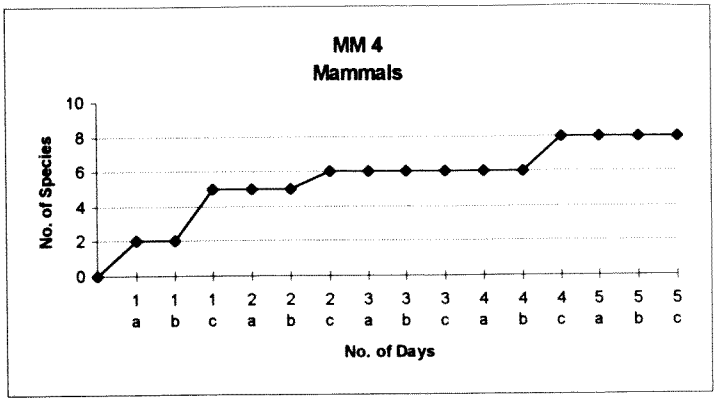
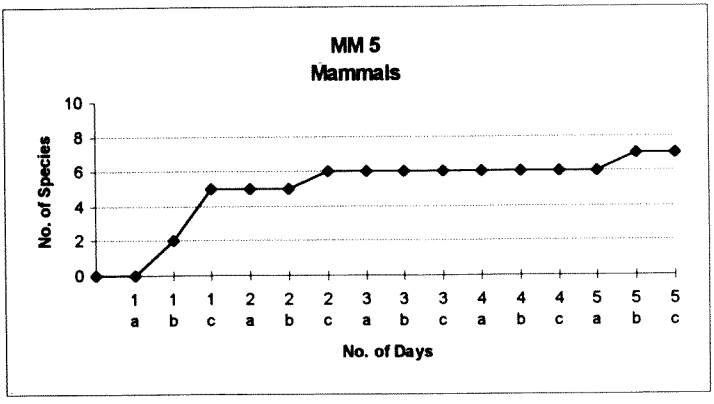


Figure 4 (cont.)





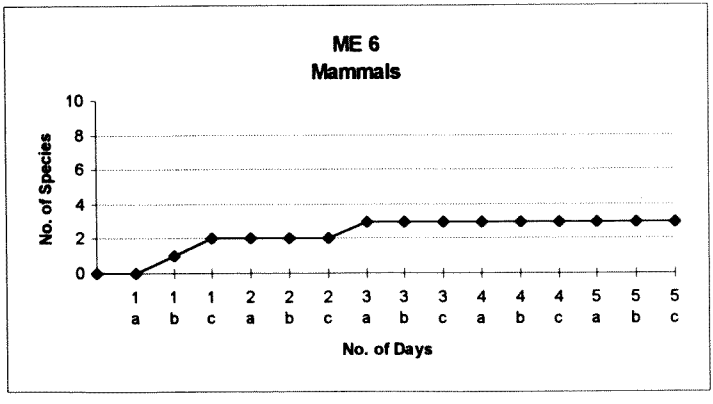
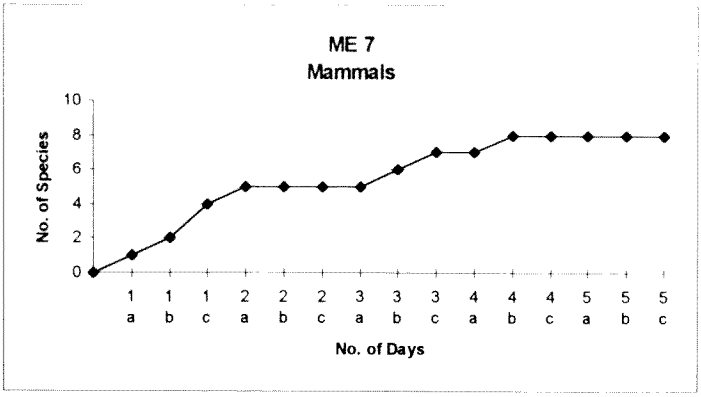
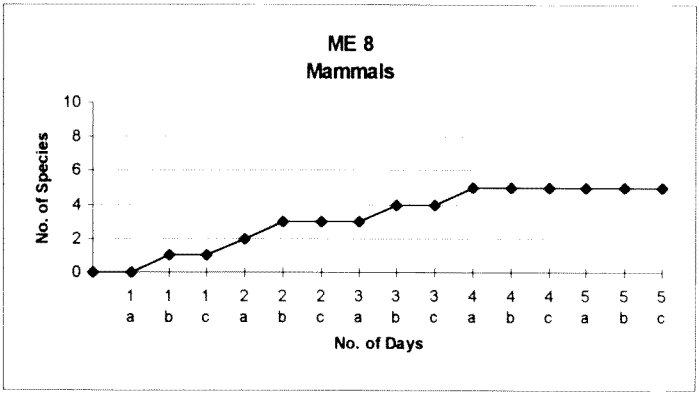


Figure 4 (cont.)





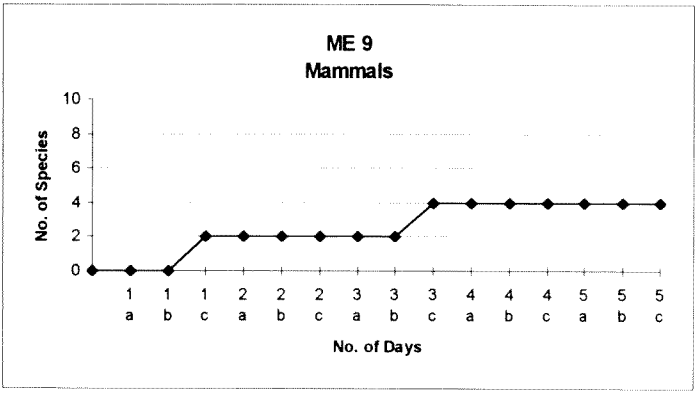


Figure 4 (cont.)

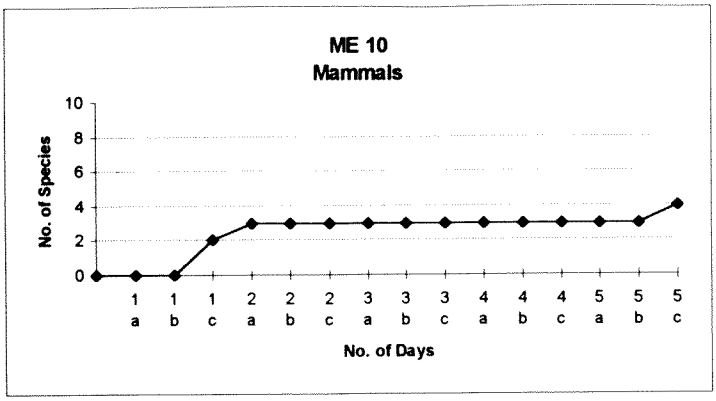


Figure 4 (cont.)

curves for some quadrats are clearly beyond a final deflection point; the small ground mammals at MM5 and ME10, and the reptiles at MM1, MM3, MM4, ME6 and ME10 appear to be under-sampled.

The analysis package PATN (Belbin 1989) was used to seek patterns of species composition in the data matrices. The clustering techniques selected were described in McKenzie *et al.* (1991b). The species assemblages from the quadrats were used as the input data. The presence and absence of species on the quadrats, rather than their relative abundance, was used because limitations in sampling techniques, aggravated by staff and time limitations, precluded reliable estimates of relative abundance (Austin 1984, McKenzie *et al.* 1991a).

Mammals

Twenty-one species of native mammal were recorded in the Study Area during the survey (Table 4). They comprised the echidna, three species of kangaroo, nine small ground-dwelling mammal species (five dasyurids and four rodents), and eight species of insectivorous bat. Seven species of introduced mammal were also encountered (including *Mus musculus*).

Only two additional species have been recorded alive in the Study Area (Table 5). Another 11 species have been identified from bone material in exposed, superficial sub-fossil deposits from 70 km north west of Mount Manning Range Nature Reserve. These were determined by Dr A. Baynes of the Western Australian Museum (Table 6) (see Henry-Hall 1990). Of these the only Kultarr and Mulgara may still persist in the Study Area. In addition, specimen records from adjacent areas in the Western Australian Museum and our knowledge of mammal distributions indicate that 11 further species of native mammals probably occurred in the Study Area at the time of first settlement by Europeans (Table 6). Only for *Leporillus* sp. was evidence found during this survey: old, abandoned stick and stone nests in breakways near the Mount Manning Range and on Mount Elvire station. Most of the species listed in Table 6 are in the Critical Weight Range and are known to have become extinct or very much rarer throughout mainland Australia since European settlement (Burbidge and McKenzie 1989).

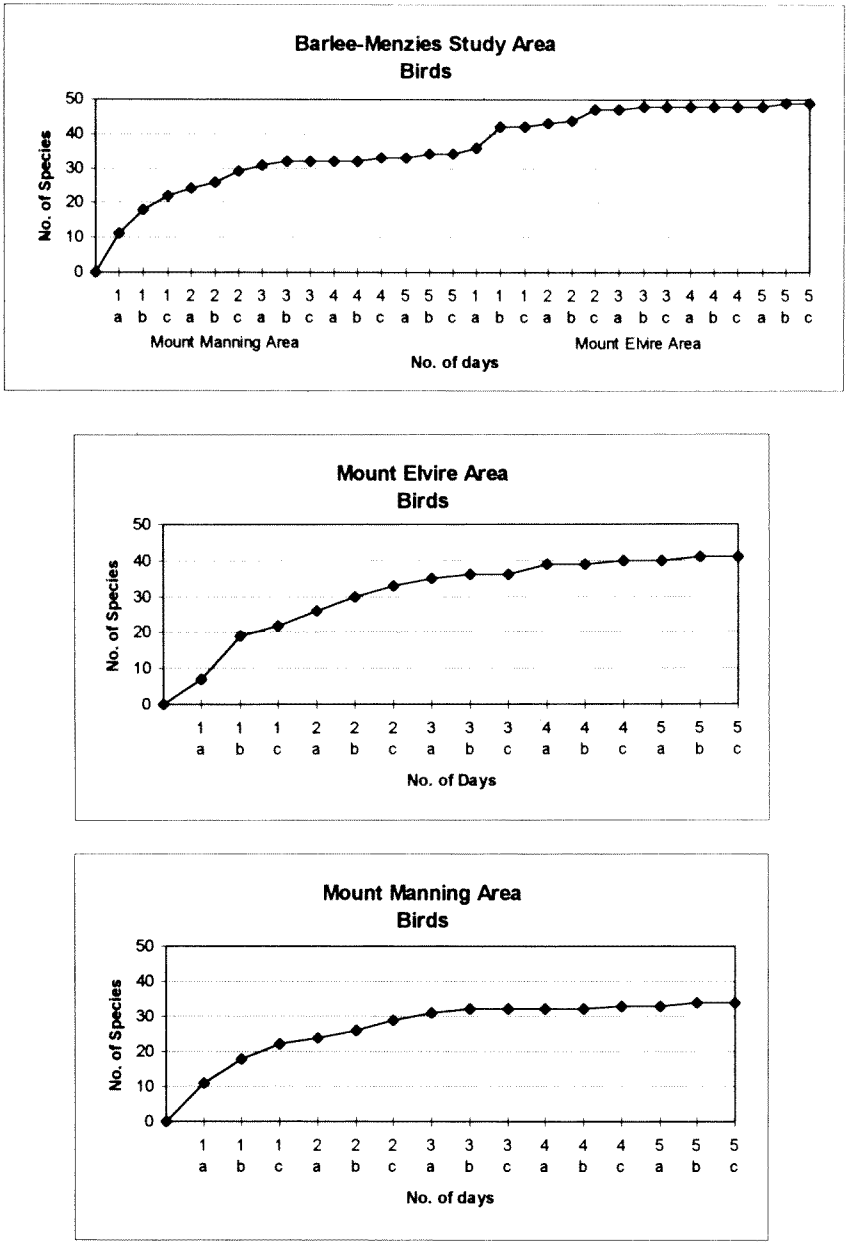
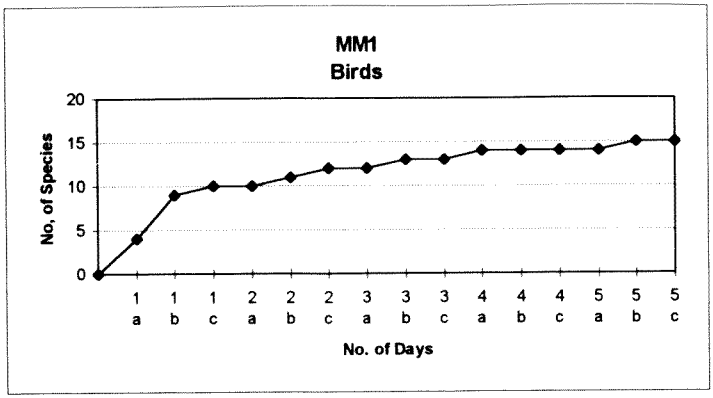
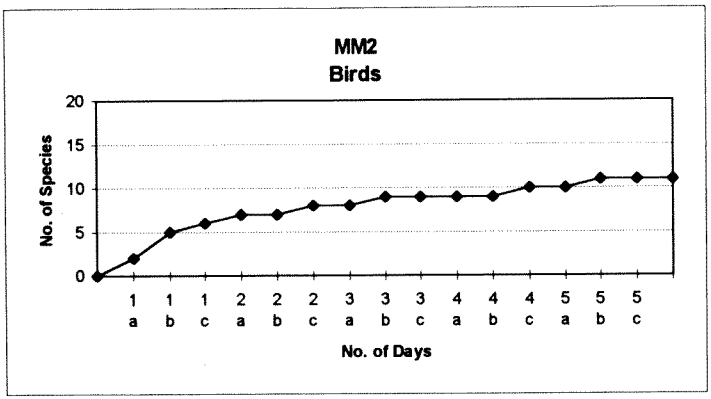


Figure 5 Species accumulation curves for passerine birds recorded recorded in the total Study Area, at the two Survey Areas and at each quadrat in the Mount Manning (MM1 - 5) and Mount Elvire (ME6 - 10) survey areas. The x-axis is 'days of effort'. The days are ordered from the first day (1) to the fifth day (5) of each sampling session: the winter (a), spring (b) and summer (c) visits.





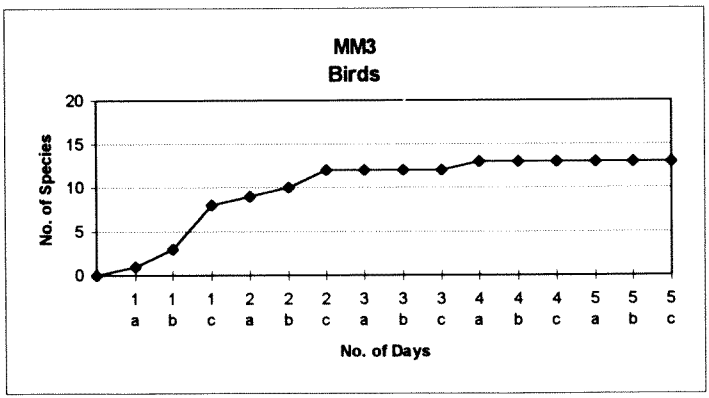
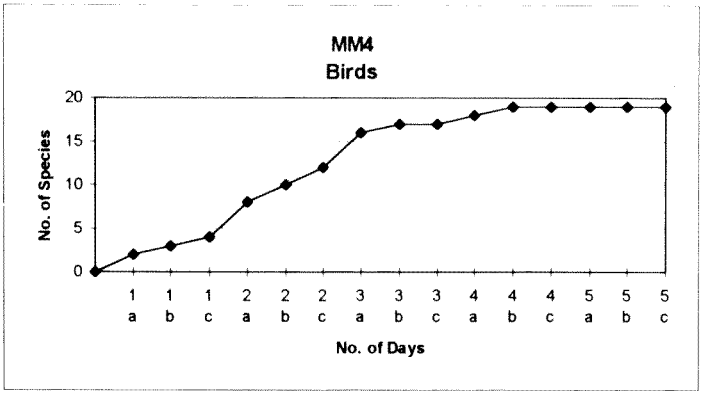
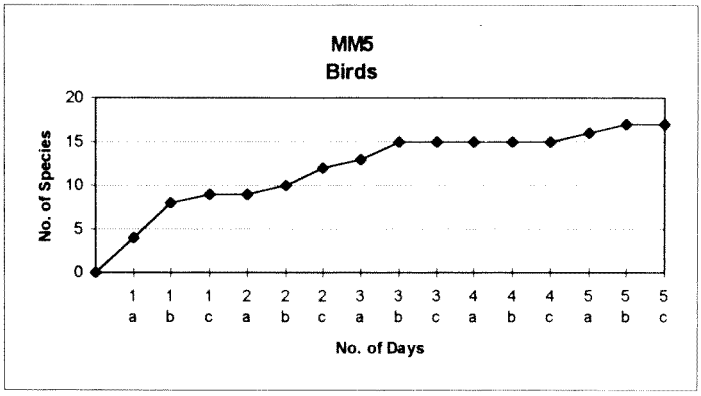


Figure 5 (cont.)





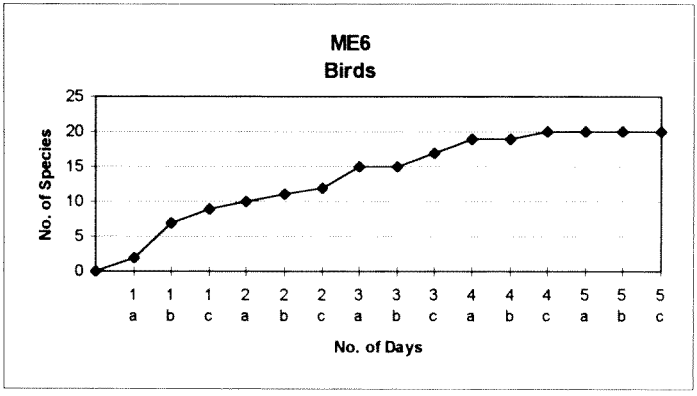
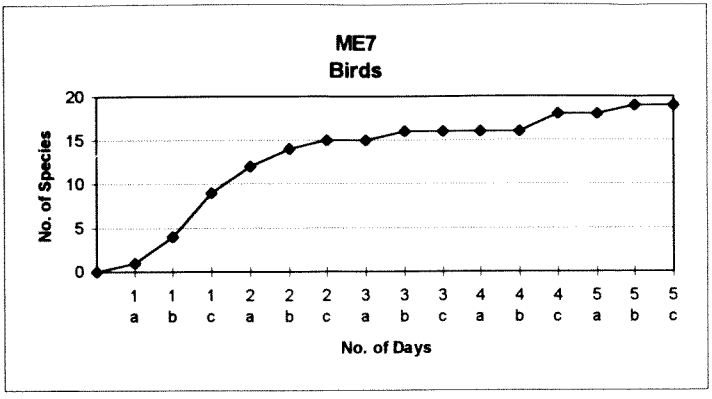
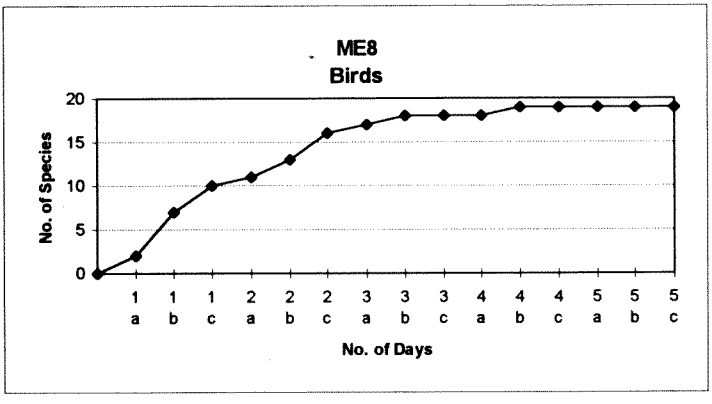


Figure 5 (cont.)





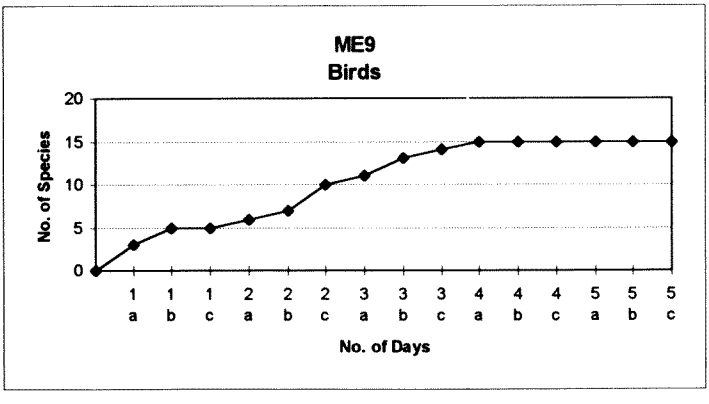


Figure 5 (cont.)

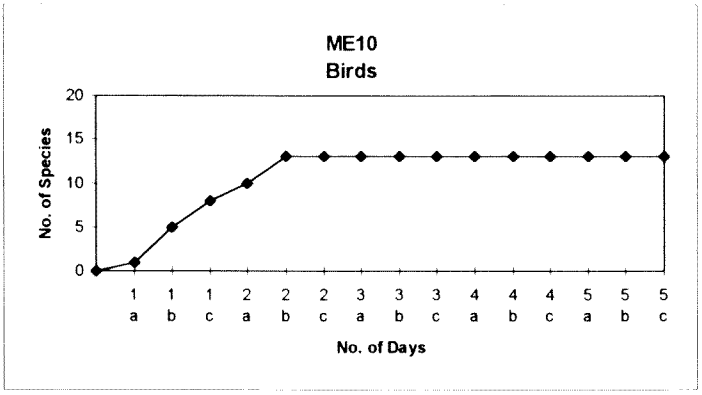


Figure 5 (cont.)

The mammals recorded are a mixture of Bassian (south western) and Eyrean species, reflecting the location of the study area on the bounday between the Coolgardie and Austin Botanical District (Keighery *et al.* this publication). Bassian species include *Ningaui yvonnae*, *Sminthopsis dolichura*, *Macropus fuliginosus*, *Pseudomys albocinereus*, *Mormopterus 'planiceps'* (SW form), *Eptesicus regulus* and *Nyctophilus major*, while Eyrean species include *Ningaui ridei*, *Sminthopsis hirtipes*, *Macropus robustus*, *Macropus rufus*, *Notomys alexis*, *Pseudomys hermannsburgensis*, *Scotorepens balstoni* and *Eptesicus baverstocki*. *Macropus fuliginosus*, *Pseudomys albocinereus*, *Eptesicus regulus* and *Nyctophilus major* were found only at the southern, Mount Manning Range, area, while *Sminthopsis crassicaudata* and *Macropus rufus* were found only at the northern, Mount Elvire, area. The species recorded only at the Mount Manning Range area are those with Bassian distributions, while the record of *Sminthopsis crassicaudata* at Mount Elvire reflects the presence of salt lake habitats in this area. As with the Kurnalpi–Kalgoorlie Study Area (McKenzie *et al.* 1992) juveniles were found in other habitats in some seasons.

Bats were sampled by using mist nets and spotlight shooting. Bats were sufficiently abundant at eight sites (of which six were remote from water) that species' assemblages could be recorded. As well, at Mount Elvire, species visiting water were recorded. The observed assemblages are listed in Table 7. A *Mormopterus 'planiceps'* was found in the gizzard of a Boobook Owl, picked up dead on a road at Mount Elvire.

Data on small ground mammals are included in Table 4: the number of specimens trapped by season for each quadrat is presented, together with information about the quadrats (landform code, lithological surface and trap-effort). The trap-effort values given at the top of this table provide a relative measure of sampling effort because virtually all small ground mammals recorded on quadrats were trapped.

The results of the numerical classifications are presented as a re-ordered data matrix in Table 8. These analyses revealed a gradient in the composition of the small ground mammal assemblages that could be explained in terms of surface lithology. The same Quaternary–Tertiary pattern of habitat usage has been noted in other Goldfields study areas (eg, McKenzie

Table 4 List of mammals recorded from the Barlee–Menzies Study Area indicating number of records in each vertebrate quadrat during each sample period, together with opportunistic mammal sightings and collections near each Camp site. The three survey periods – winter (July–August 1979), spring (September 1980) and summer (March 1981) – are indicated in columns 1, 2 and 3 respectively for each surface type or camp site.

Vertebrate quadrat	**MM[1]**	MM1[2]	MM2	MM3	MM4	MM5
Vegetation quadrat		BM16	BM6	BM5	BM20	BM12
Landform code		UN	HI	HI	V	S
Lithological surface		Qc	Aiw	Qtc	Qz	Ts
Drift fence nights		5 5 5	5 5 5	5 10 10	5 10 10	5 10 10
TACHYGLOSSIDAE						
Tachyglossus aculeatus	x x x					
DASYURIDAE						
Ningaui ridei				– 2 –	1 4 –	
Ningaui yvonneae	x – –			– – 1	2 2 –	– 1 1
Sminthopsis hirtipes	– – *				– – 1	1 1 3
Sminthopsis dolichura	x – x	– – 1		1 1 2	1 – 1	1 4 3
Sminthopsis crassicaudata						
MACROPODIDAE						
Macropus fuliginosus	– – x					
Macropus robustus	– – x					
Macropus rufus						
MOLOSSIDAE						
Tadarida australis	x x x	– 3 –				
Mormopterus 'planiceps' (SW)	– x x	– – 1				
VESPERTILIONIDAE						
Chalinolobus gouldii	– x x	– 1 –			– – 1	
Scotorepens balstoni	– x x	– 1 –				
Eptesicus baverstocki	– x –					
Eptesicus regulus	– x x					
Nyctophilus geoffroyi	– x –					
Nyctophilus major	– – x					
MURIDAE						
Notomys alexis	– – *			1 – 1	– – 2	– 1 5
Pseudomys hermannsburgensis	– – *					
Pseudomys albocinereus	– – *					1 3 8
Pseudomys bolami					– – 1	
Mus musculus	– – x	2 – 3	2 – 1		– – 3	– – 1
CANIDAE						
Canis familiaris dingo	x x x					
Vulpes vulpes	x x x					
FELIDAE						
Felis catus	– – x					
LEPORIDAE						
Oryctolagus cuniculus	x x x					
BOVIDAE						
Capra hircus						
Ovis aries						
TOTAL SPP/SITE OR QUADRAT	**22**	1 3 3	1 0 1	2 2 3	3 2 6	3 5 6

Key:

1 Opportunistic records from camp site and environs (not on quadrats); MM = Mount Manning range, ME = Mount Elvire

2 Vertebrate quadrat

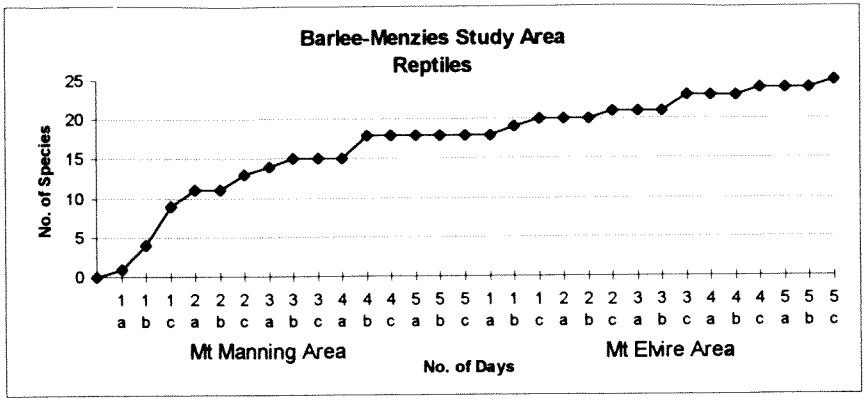
* Trapped 16 September 1981 on sandplain east of Mount Manning Range (Vegetation quadrat BM14)

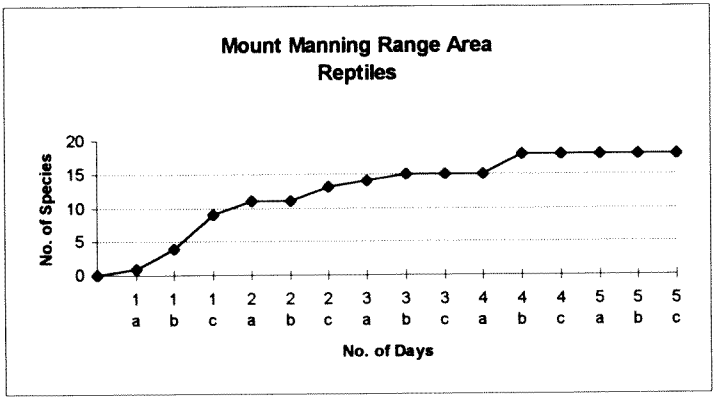
ME[1]	ME6 BM21 V Qc 5 10 10	ME7 BM13 S Ts 10 10 10	ME8 BM23 V Qs 5 10 10	ME9 BM3 G Ag 5 5 5	ME10 BM10 L Qg 5 5 5	TOTAL
x x –						
		1 2 2				**2 8 2**
		– 2 –				**2 5 2**
		2 – 1	– 1 –			**3 2 5**
	3 1 1	3 1 –	2 1 –	– – 2	1 – –	**12 8 10**
		– 1 –	– 1 –	– – 2	2 2 1	**2 4 3**
– – x						
x x x						
– – x				1 2 –		1 5 0
– – x						0 0 1
– x x				2 5 –		2 6 1
– – x				2 5 –		2 6 0
				1 1 –		1 1 0
– x –				2 1 –		2 1 0
	7 – 2	4 5 9	5 3 8		– – 2	**17 9 29**
		– – 1				**0 0 1**
						1 3 8
				– – 1		**0 0 2**
	2 – –	1 – 3	2 – –	– – 2	4 1 4	**13 1 17**
– x x						
x x x						
– – x						
x x x						
x – x						
x x x						
14	3 1 2	5 5 5	3 4 1	5 5 4	3 2 3	**60 59 81**

Notes:

1 Specimens of two *Pseudomys*, field number FW5284 from MM4 and FW5286 from MM3 have not been located. They are not included in this table.

2 Four *Ningaui* from MM4 and one from MM5 were released and could have been either *N. ridei* or *N. yvonnae*. They are not included in this table.





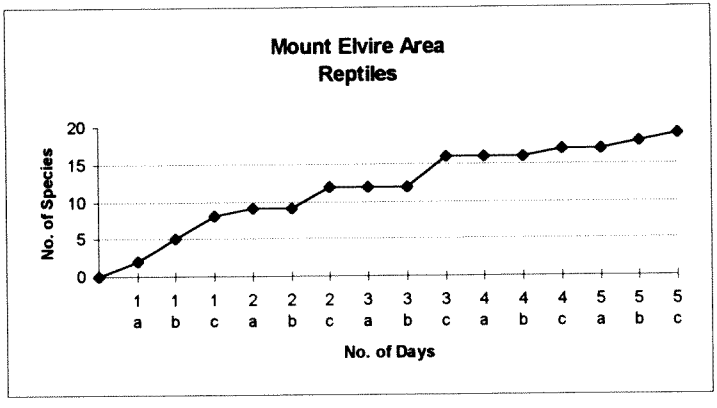
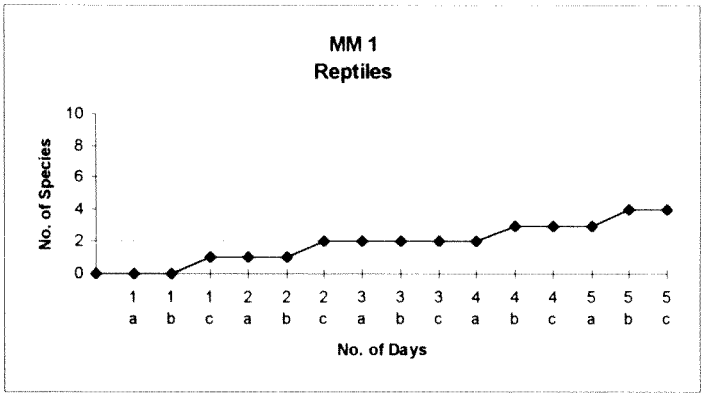
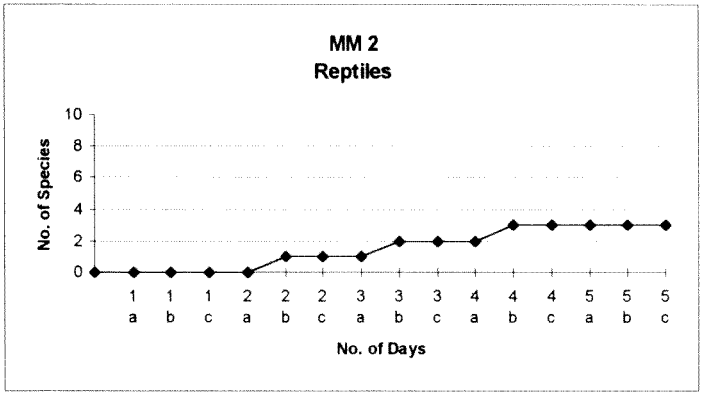


Figure 6 Species accumulation curves for lizards (excluding varanids and legless lizards) recorded recorded in the total Study Area, at the two Survey Areas and at each quadrat in the Mount Manning (MM1 - 5) and Mount Elvire (ME6 - 10) survey areas. The x-axis is 'days of effort'. The days are ordered from the first day (1) to the fifth day (5) of each sampling session: the winter (a), spring (b) and summer (c) visits.





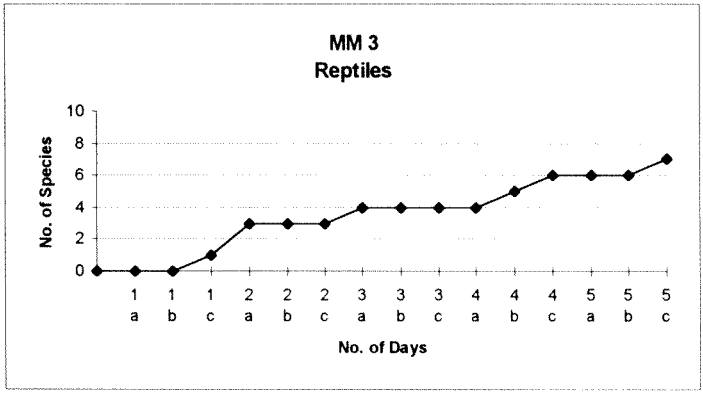
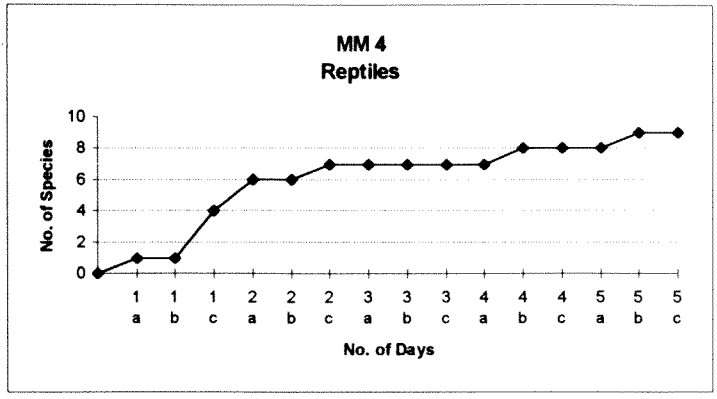
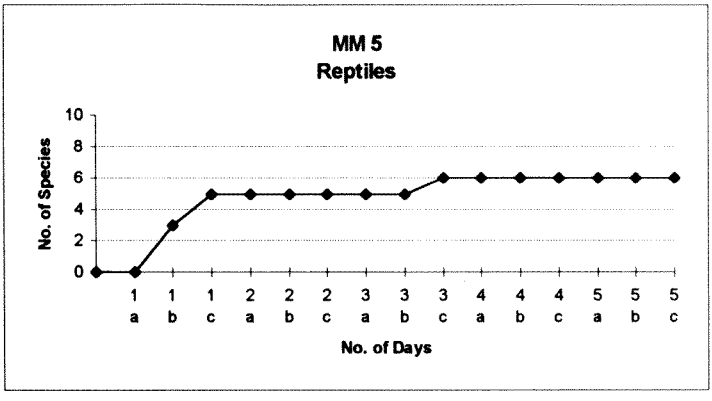


Figure 6 (cont.)





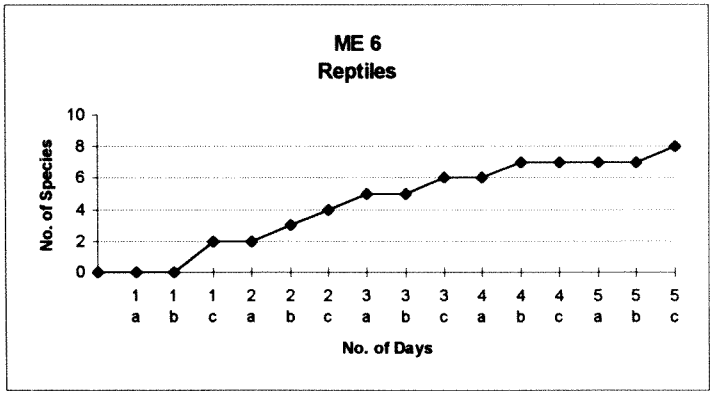
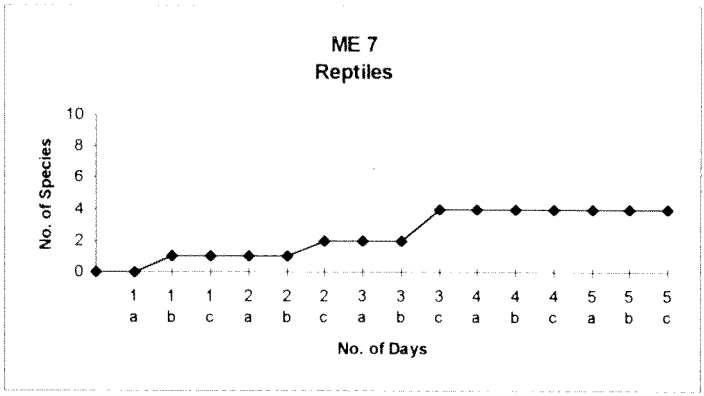
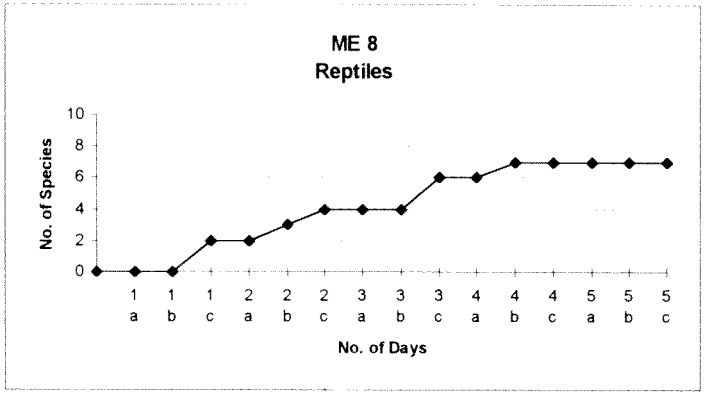


Figure 6 (cont.)





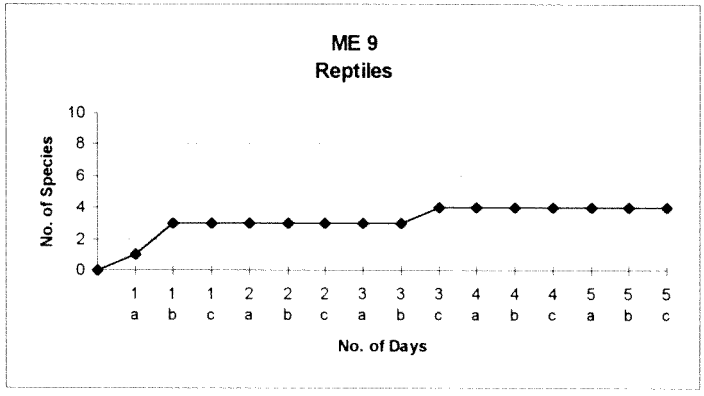


Figure 6 (cont.)

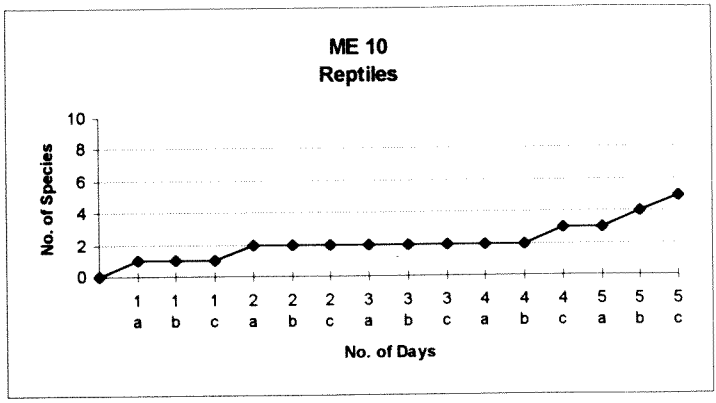


Figure 6 (cont.)

et al. 1992). Sandy surfaces derived from or including Tertiary material (Ts at quadrats MM5 & ME7, Qtc at MM3) mantle the upper levels in the landscape, and occur as spillway deposits lower in the landscape where they mix with Quaternary surfaces (see Appendix 1 description of the Qz surface at MM4) or fringe outcrops (Qtc/Aiw at MM3). The Tertiary sandy surfaces were characterised by *Ningaui ridei, N. yvonneae, Sminthopsis hirtipes* and *Pseudomys hermannsburgensis*. As observed elsewhere in the Goldfields, *Sminthopsis dolichura* occurs on both Tertiary and Quaternary lithologies.

The lower levels in the landscape are Quaternary surfaces, expressed as plains (Qz at MM4) and valley floors (Qc at MM1 & ME6) of heavy soils, or as sand sheets and dunes on the plains (Qs at ME8) or peripheral to salt lakes (Qg (=Qs–Qra) at ME10). *Mus musculus, Pseudomys bolami* and *S. crassicaudata* characterise these, although *Notomys alexis* and *S. hirtipes* (where adjacent to Ts) also occur on the Quaternary sands. After good years, as were experienced during this survey, it appears that these Quaternary species increase in density and widen their habitat usage to include Tertiary surfaces (mainly the sub-adults) (Rosenweig & Abramsky 1985). McKenzie *et al.* (1992) noted a similar expansion in habitat use for *Sminthopsis crassicaudata. Pseudomys albocinereus* was recorded only at one Quadrat, MM5. This species is at the north-western limit of its distribution.

Table 5 Other mammal species recorded from the Barlee-Menzies Study Area.

Species	Specimen or source	Location
Peudantechinus woolleyae	1	3.5 km at 165° from Mt Elvire, banded ironstone ridge
Chalinolobus morio	M4716	Pigeon Rocks

1 CALM Goldfields Region reserve fauna recording system; trapped and released. Specimen M4716 lodged at Western Australian Museum

Table 6 Mammals that probably once occurred in the Barlee-Menzies Study Area, but which are now locally or totally extinct.

Dasyurus geoffroii, Chuditch
* *Dasycercus cristicauda*, Mulgara
* *Phascogale calura*, Red-tailed Phascogale
* *Sminthopsis psammophila*, Sandhill Dunnart
* *Antechinomys laniger*, Kultarr
Myrmecobius fasciatus, Numbat
* *Chaeropus ecaudatus*, Kantjilpa or Pig-footed Bandicoot
* *Perameles bougainville*, Western Barred Bandicoot
Macrotis lagotis, Bilby
Trichosurus vulpecula, Wayurta or Common Brushtail Possum
Bettongia lesueur, Boodie
Bettongia penicillata, Woylie
Lagorchestes hirsutus, Mala
Onychogalea lunata, Tjawalpa or Crescent Nailtail Wallaby
Petrogale lateralis, Warru or Black-footed Rock-wallaby
* *Leporillus apicalis*, Djooyalpi or Lesser Sticknest Rat
* *Leporillus conditor*, Wopilkara or Greater Sticknest Rat
* *Notomys amplus*, Yoontoo or Short-tailed Hopping-mouse
Notomys longicaudatus, Koolawa or Long-tailed Hopping-mouse
* *Pseudomys desertor*, Wildjin or Desert Mouse
* *Pseudomys fieldi*, Djoongari or Shark Bay Mouse
Pseudomys gouldii, Koontin or Gould's Mouse

Vernacular names for rodents from Braithwaite *et al.* in press.
* Recorded in surface cave deposits, 70 km north west of Mount Manning Range Nature Reserve (see text)

Table 7 Bat species recorded from the Mount Manning Range and Mount Elvire survey areas during the survey of the Barlee-Menzies Study Area.

SITE[a]	1	2	3	4	5	6	7	8
Tadarida australis		x		x	x	x	x	x
Mormopterus 'planiceps' (SW)	x	x		x	x	x		x
Chalinolobus gouldii		x	x	x	x	x	x	x
Scotorepens balstoni	x			x	x	x	x	x
Eptesicus baverstocki		x					x	
Eptesicus regulus		x	x					
Nyctophilus geoffroyi	x						x	
Nyctophilus major		#	x					

[a] 1 sandplain with emergent mallee, 29°59'S, 119°33'E
2 Die Hardy Range, pass, low open scrub 29°57'S, 119°23'E
3 Olby Rock, 29°57'30"S, 119°26'30"E
4 dry claypan surrounded by mallee, 29°59'S, 119°32'E
5 MM1, *E. salubris* woodland
6 *E. salmonophloia* woodland, 30°00'S, 119°43'E
7 ME9, granite rock with pool
8 small dam, 29°25'S, 119°35'E

collected 16 March 1978

Table 8 Data matrix of small ground-dwelling mammals re-ordered according to UPGMA classification outputs (Belbin 1989). The quadrats were classified according to similarities in their species composition, and the species according to the co-occurrence at the same quadrats.

Species	Quadrat Code[1]		
	MMMMM	MMMM	M
	MEEEE	MMEM	M
	16819	3475	2
	0		
Ningaui ridei		* * *	
Ningaui yvonneae		* * * *	
Sminthopsis hirtipes	*	* * *	
Pseudomys hermannsburgensis		*	
Sminthopsis dolichura	* * * * *	* * * *	
Mus musculus	* * * * *	* * *	*
Notomys alexis	* * *	* * * *	
Sminthopsis crassicaudata	* * *	*	
Pseudomys bolami	*	*	
Pseudomys albocinereus		*	
Lihological origin[2]	QQQQQ	TQTT	A

[1] Quadrat codes printed vertically

[2] Q = Quaternary; T = Tertiary; A = Archaean outcrop; MM3 surface is Quaternary re-working of Tertiary alluvium (Qtc) (Walker & Blight 1983). MM4 is Qz. ME9 is a granite complex - with Quaternary soils associated with Archaean rocks.

Only one small ground mammal (*Mus musculus*) was recorded at Quadrat MM2, which was located on the slopes of Mt Manning Range (Aiw). Pit-fence traps could not be set at this site because of the lack of soil; instead drift fences with funnel traps were used. Because of the different trapping methodologies and correspondingly different trapping efficiency, the quantitative data from this Quadrat could have been ignored.

Birds

One hundred and fourteen species of bird were recorded in the Barlee–Menzies Study Area during our survey (52 non-passerines and 62 passerines). Fifty eight of these were recorded on quadrats (17 non-passerines and 41 passerines (Table 9)). The Study Area lies across the boundary of the Coolgardie and Austin Botanical Districts, so Eyrean and Bassian components are both well represented. A search for records made prior to and since our visit revealed that another 22 species have been recorded in the Study Area (11 non-passerines and 11 passerines, see Table 10). Thus a total of 136 species of birds (63 non-passerines and 73 passerines) have been recorded in the Study Area. Seventy-eight of these (46 non-passerines and 32 passerines) were not recorded on quadrats during our surveys (Table 3).

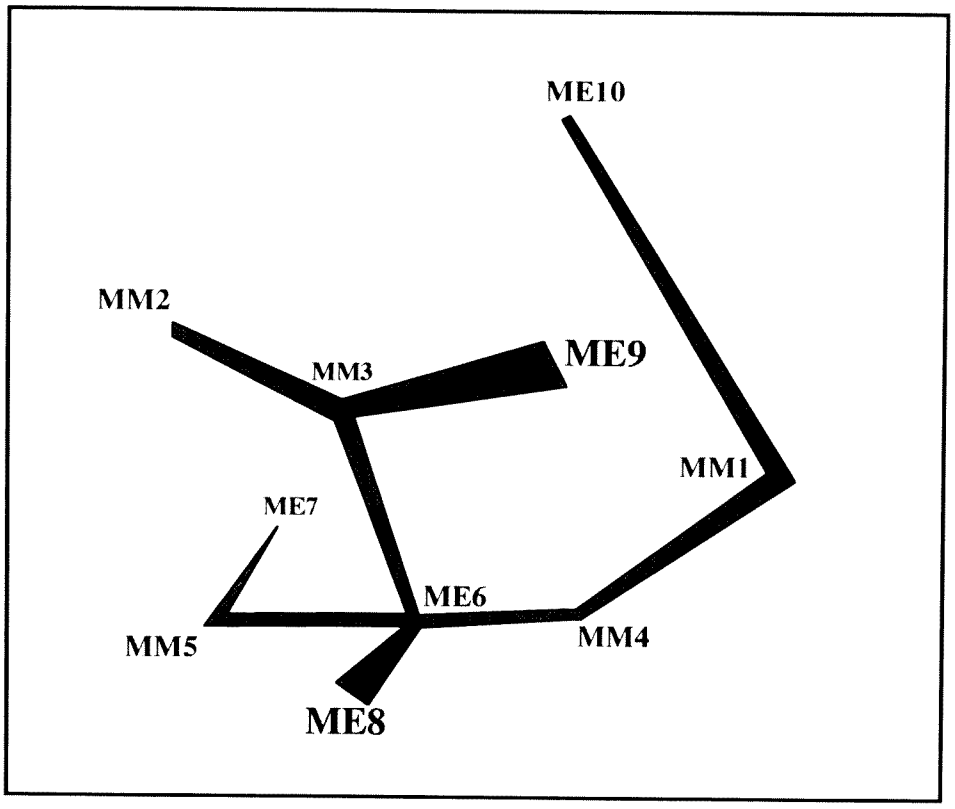


Figure 7 Three-dimensional ordination of the passerine bird data. Stress=0.125. Sites are ordinated according to similarities in their species composition. A Minimum Spanning Tree has been superimposed. Branch widths represent projections into the 3rd dimension. See text for details of analyses.

KEY (from Appendix 1):

Quaternary soils

ME10: Salt Lake Features. *Qg*, a mozaic of saline alluvium (*Qra*) and sand lunettes (*Qas*).
MM1: Undulating Plains. Calcareous colluvial plain (*Qc*).
MM4: Broad Valleys. Plain of red sandy loam (*Qz*).
ME6: Broad Valleys. Plain of calcareous colluvium (*Qc*) mantled by red sandy loam.
ME8: Broad Valleys. Sand sheet (*Qs*) adjacent to lower edge of Tertiary sand sheet (*Ts*).

Tertiary sand

MM5: Sandplains. Yellow sandplain (Ts).
ME7: Sandplains. Reddish sand sheet (Ts).

Outcrop surfaces and foot-slopes

MM3: Hills, Banded Ironstone. Stony colluvium (Qtc) at foot of range (Aiw).
MM2: Hills, Banded Ironstone. Scree-slopes of range (Aiw).
ME9: Granite complex. Sheet exposures with shallow sandy loam (Ag).

Table 9 Species of birds recorded from the Barlee-Menzies Study Area, indicating number of sightings made in each vertebrate quadrat during each sample period, together with opportunistic bird sightings near each Camp site. The three survey periods - winter (July-August 1979), spring (September 1980) and summer (March 1981) – are indicated in columns 1, 2 and 3 respectively for each quadrat[1] or camp site.

Vertebrate quadrat	MM[2]			MM1	MM2	MM3	MM4	MM5		
Vegetation quadrat				BM16	BM6	BM5	BM20	BM12		
Landform code				UN	HI	HI	V	S		
Lithological surface				Qc	Aiw	Qtc	Qz	Ts		
NON-PASSERINES										
Emu	x	x	x							
Hoary-headed Grebe										
Pacific Heron										
White-faced Heron										
Black Swan										
Australian Shelduck										
Pacific Black Duck										
Grey Teal										
Pink-eared Duck										
Hardhead										
Maned Duck										
Square-tailed Kite		x								
Black-breasted Buzzard		x								
Whistling Kite	x									
Brown Goshawk	x									
Collared Sparrowhawk			x							
Wedge-tailed Eagle		x								
Little Eagle		x								
Spotted Harrier										
Peregrine Falcon		x								
Australian Hobby		x	x						-	1 -
Brown Falcon		x	x						-	- 1
Australian Kestrel	x	x	x							
Malleefowl										
Quail (? sp.)		x	x							
Little Button-quail		x								
Eurasian Coot										
Banded Lapwing		x								
Red-kneed Plover										
Hooded Plover										
Red-capped Plover										
Black-fronted Plover										
Black-winged Stilt		x								
Banded Stilt										
Red-necked Avocet										
Silver Gull										
Common Bronzewing			x							

* Breeding recorded (bird carrying nesting material, new nest, nest with eggs or chicks, dependent chicks)

1 Each quadrat was sampled for one hour on each of five days over three seasons

2 Opportunistic sightings, not on quadrats; MM = Mount Manning Range Study Area, ME = Mount Elvire Study Area

ME[2]	ME6 BM21 V Qc	ME7 BM13 S Ts	ME8 BM23 V Qs	ME9 BM3 G Ag	ME10 BM10 L Qg	TOTAL
x* x* x						
x*						
x						
x						
x*						
x*						
x						
x*					- 1 -	**0 1 0**
x*						
x						
x*						
x						
x x				- 2 -		**0 2 0**
x x* x				- - 1		**0 0 1**
x x						
x						
x						
x*						**0 1 0**
x x x						**0 0 1**
x* x				- - 1	- 1 -	**0 1 1**
x						
x*			- 1 -		- 1 -	**0 2 0**
x						
x*				- 1 -		**0 1 0**
x*						
x						
x*						
x						
x*						
x*						
x*						
x						
x x* x			- 3 2			**0 3 2**

Table 9 (cont.)

Vertebrate quadrat	MM[2]			MM1			MM2			MM3			MM4			MM5		
Vegetation quadrat				BM16			BM6			BM5			BM20			BM12		
Landform code				UN			HI			HI			V			S		
Lithological surface				Qc			Aiw			Qtc			Qz			Ts		
Crested Pigeon																		
Galah		x	x*	-	3	-							-	1	-	-	1	-
Cockatiel																		
Budgerigar																		
Port Lincoln Ringneck	x	x	x	1	4	1				1	-	1						
Mulga Parrot	x		x															
Bourke's Parrot																		
Scarlet-chested Parrot				-	1	-												
Pallid Cuckoo		x		-	3	-							-	1	-			
Horsfield's Bronze-Cuckoo		x*														-	1	-
Southern Boobook		x	x															
Tawny Frogmouth		x	x							-	-	1				-	2	-
Australian Owlet-nightjar	x	x	x															
Spotted Nightjar		x	x															
Red-backed Kingfisher		x																
PASSERINES																		
Rainbow Bee-eater																		
Welcome Swallow																		
Tree Martin		x*		-	2*	-												
Fairy Martin																		
Richard's Pipit		x																
Black-faced Cuckoo-shrike		x*	x	-	3	-							-	1	-			
Ground Cuckoo-shrike																		
White-winged Triller		x														-	1	-
Red-capped Robin	x	x*	x	-	1	-				2	-	1	1	-	1	1	-	3
Hooded Robin	x	x*	x	1	-	1				-	-	2						
Jacky Winter	x	x		2	-	1							2	-	-	1	-	-
Gilbert's Whistler																-	-	1
Rufous Whistler		x	x				-	1	-	-	-	2	-	1	-	-	2	-
Grey Shrike-thrush	x*	x	x				1	1	1	1	-	-				1	1	-
Crested Bellbird	x	x*	x							-	-	1				1	-	-
Grey Fantail	x		x				1	-	-	-	-	1						
Willie Wagtail	x	x*	x				-	2	1	-	-	2						
Chestnut Quail-thrush		x	x													-	1	-
White-browed Babbler																		
Rufous Songlark																		
Brown Songlark																		
Splendid Fairy-wren																		
Variegated Fairy-wren																		
White-winged Fairy-wren		x	x															
Redthroat		x														-	-	1

* Breeding recorded (bird carrying nesting material, new nest, nest with eggs or chicks, dependent chicks)

1 Each quadrat was sampled for one hour on each of five days over three seasons

2 Opportunistic sightings, not on quadrats; MM = Mount Manning Range Study Area, ME = Mount Elvire Study Area

ME[2]			ME6 BM21 V Qc	ME7 BM13 S Ts	ME8 BM23 V Qs	ME9 BM3 G Ag	ME10 BM10 L Qg	TOTAL
x	x	x						
x	x*	x	- 3 4	1 - 3	- - 4	1 2 4		**2 10 15**
		x				- 1 -	- 1 -	**0 2 0**
	x*							
x	x	x		- 1 2	1 - 2	2 - 2	1 - -	**6 5 8**
x	x*	x			- 1 3			**0 1 3**
	x*	x						
								0 1 0
	x*							**0 4 0**
	x*				- 2 -			**0 3 0**
		x						
	x	x						**0 2 1**
x	x	x						
	x	x						
	x							
	x		- - 1					**0 0 1**
	x							
	x	x						**0 2 0**
	x*							
x	x	x				- 2 1		**0 2 1**
	x*	x	- - 1					**0 4 1**
		x						
	x*			- 1* -	- 1 -			**0 3 0**
x	x*	x	- 2 -	- 1 1	1 3* 1	- 4 -	1 3 -	**6 14 7**
x	x*						1 - 4	**2 0 7**
x	x	x						**5 0 1**
								0 0 1
x	x*		1 3 -	- 2 -	- 4 -			**1 13 2**
x	x*	x	1 - -	3 1 1				**7 3 2**
x	x*	x	1 - 1	1 1 -	3 1 -	2 - -		**8 2 2**
x	x*		2 2 2	1 1 2	- 3 -			**4 6 5**
x	x*	x				1 - -		**1 2 3**
				1 - 2				**1 1 2**
x	x							
	x*							
	x							
x	x*							
x	x							
							1 2 2	**1 2 2**
x	x*			2 2 -	- - 2			**2 2 3**

Table 9 (cont.)

Vertebrate quadrat Vegetation quadrat Landform code Lithological surface	MM[2]	MM1 BM16 UN Qc	MM2 BM6 HI Aiw	MM3 BM5 HI Qtc	MM4 BM20 V Qz	MM5 BM12 S Ts
Weebill	x x x	4 - 5		- 4 -	5 2 5	1 3 1
Western Gerygone						
Inland Thornbill	x x		4 - 5	1 1 2	2 1 -	2 3* 2
Chestnut-rumped Thornbill	x x x		1 - -	- 1 2	- 1 1	- - 2
Slender-billed Thornbill						
Yellow-rumped Thornbill	x* x					
Southern Whiteface	x x				- - 1	
Varied Sittella	x x				1 - -	
White-browed Treecreeper	x x x					
Rufous Treecreeper	x x x	1 3 3				
Red Wattlebird	x x					
Spiny-cheeked Honeyeater	x x* x	- 3 -	- 1 -	- 3 1	1 1 4	- 3 1
Yellow-throated Miner	x x x					
Singing Honeyeater	x x x		1 4 2		1 - -	
White-eared Honeyeater	x x x				2 - 1	2 - -
Grey-fronted Honeyeater	x					
Yellow-plumed Honeyeater	x x* x	3 - 4			- - 1	
Brown-headed Honeyeater	x x				1 - -	
Brown Honeyeater	x					
White-fronted Honeyeater	x* x	- 1 -	- 6 4	- 3 4	- 1 2	- 4* 2
Black Honeyeater						
Pied Honeyeater	x					
Crimson Chat						
White-fronted Chat						
Mistletoebird			- 1 -		- 1 -	
Striated Pardalote	x x*	4 3 1			1 - -	
Zebra Finch						
Australian Magpie-lark						
Masked Woodswallow	x					
Black-faced Woodswallow	x x x					1 - -
Dusky Woodswallow	x					
Little Woodswallow	x					
Grey Butcherbird	x x x		- - 1			
Pied Butcherbird	x x* x	- 2 3			1 - -	
Australian Magpie	x					
Grey Currawong	x x x					
Little Crow	x* x					
TOTAL SPECIES/QUADRAT		7 12 8	5 7 6	4 5 12	11 10 8	8 12 9
Species richness	71	16	11	14	20	21

* Breeding recorded (bird carrying nesting material, new nest, nest with eggs or chicks, dependent chicks)

1 Each quadrat was sampled for one hour on each of five days over three seasons

2 Opportunistic sightings, not on quadrats; MM = Mount Manning Range Study Area, ME = Mount Elvire Study Area

ME[2]			ME6 BM21 V Qc	ME7 BM13 S Ts	ME8 BM23 V Qs	ME9 BM3 G Ag	ME10 BM10 L Qg	TOTAL
x	x	x	5 5 5	1 2* 4	- - 1	- - 1		**16 16 22**
				- 1 -				**0 1 0**
	x*	x	- 1 1	1 - 3	- 1 -			**10 7 13**
	x*	x	2 5 4	1 1 -	2 4* 3	2 1 3		**8 13 15**
	x	x						
x*	x*	x						
x	x*	x			- 1 -	- 2 -		**0 3 1**
	x	x						**1 0 0**
x	x*	x	- 1 -					**0 1 0**
	x							**1 3 3**
x	x*	x	1 1 1		- 1 -	1 5 1	- 1 1	**3 19 9**
x	x*	x	2 - 4		1 - -			**3 0 4**
x	x*	x	1 - 1	- - 1	- - 1		2 - -	**5 4 5**
x		x	1 - 1					**5 0 2**
	x		1 - -					**4 0 5**
			1 1 -	- - 2				**2 1 2**
	x							
	x*	x	- - 2	- 7* 1			- 3 3	**0 25 18**
	x*			- 2* -			- 2 -	**0 4 0**
	x*					- 2 -	- 3 -	**0 5 0**
	x*							
	x*						- 3 -	**0 3 0**
	x							**0 2 0**
x	x							**5 3 1**
	x*	x		- - 1		2 - 2		**2 0 3**
x								
	x*							
x	x*	x					- 1 2	**1 1 2**
	x							
x	x	x				1 - -		**1 0 1**
x	x*	x	- - 1		1 - -			**2 2 4**
x	x*							
x		x						
x								
			12 10 14	9 13 12	6 13 9	8 10 10	5 12 5	
100			20	19	20	18	15	

Table 10 Additional bird species recorded from the Barlee-Menzies Study Area.

Species	Source
NON-PASSERINES	
Black-shouldered Kite	2
Black-tailed Native-hen	4
Australian Bustard	1,5
Inland Dotterel	2
Greenshank	1
Diamond Dove	4
Red-tailed Black-Cockatoo	1,2
Pink Cockatoo	2,5
Purple-crowned Lorikeet	5
Black-eared Cuckoo	1,5
Barn Owl	1
PASSERINES	
White-backed Swallow	1,4
Western Yellow Robin	5
Golden Whistler	5
Southern Scrub-robin	2
Chiming Wedgebill	1
Cinnamon Quail-thrush	1,3,5
Slaty-backed Thornbill	1
Orange Chat	1,2
Silvereye	2
Painted Firetail	2
Australian Raven	1

1 Atlas of Australian Birds 1977-1981 (Blakers *et al.* 1984)*
2 Atlas of Australian Birds 1951-1976 (RAOU, Melbourne)*
3 Atlas of Australian Birds 1901-1950 (RAOU, Melbourne)*
4 CALM Goldfields Region reserve fauna recording system - Mt Elvire State Forest
5 Storr (1985)†

* Because of the way in which RAOU Bird Atlas data was collected, some records may be from a short distance outside the study area.
† Records are only included if they were specifically listed from localities within the Study Area.

Twenty-two of the 46 non-passerines not recorded on quadrats are waterbirds; habitats frequented by such species were inadequately sampled during our field work. Of the other non-passerines, the Malleefowl is at the edge of its current range (it now being confined to the south west corner of the State), the Red-tailed Black-Cockatoo and Purple-crowned Lorikeet do not extend further inland, while the Black-breasted Buzzard, Bourke's Parrot, Scarlet-chested Parrot and Diamond Dove do not extend further to the south west.

Of the 32 passerines we did not record on quadrats, the Western Yellow Robin, Southern Scrub-robin, Gilbert's Whistler, Golden Whistler, Chestnut Quail-Thrush, Rufous Treecreeper, Red Wattlebird, White-eared Honeyeater, Yellow-plumed Honeyeater, Brown-headed Honeyeater, Silvereye, Painted Firetail and Dusky Woodswallow are at the inland or northern limits of their range and the Cinnamon Quail-Thrush, Variegated Fairy-wren, Slaty-backed Thornbill, Slender-billed Thornbill, White-browed Treecreeper, Black Honeyeater,

Pied Honeyeater, and Little Woodswallow are at or near the south western limits of their ranges.

Non-passerines were poorly represented in our samples; overall, 83% of known species were recorded, but only 27% were recorded on quadrats (Table 3). The quadrat-based strategy of survey was expected to be more effective for sampling relatively sedentary species with smaller home ranges and therefore greater densities in suitable habitat. This was reflected by us recording 41 of 73 (56%) species of passerines known from the Study Area. Sampling was restricted to 10 quadrats, each of only 4 000m^2, representing only a small fraction of the surface-types recognised from the geological maps (see Table 2).

The birds recorded on the quadrats are listed in Table 9. A total of 29 (27 passerine) species were recorded in winter 1979, 46 (31) in spring 1980, and 40 (32) in summer 1981. The number of species recorded was strongly influenced by rainfall; during the winter of 1980 there was a long period of good rains. This is particularly so in the case of non-passerine waterbirds, many of which were recorded on Lake Barlee and other wetlands during our spring 1980 visit. The number of individuals of some species also increased during spring 1980; these included Red-capped Robin, Rufous Whistler, Spiny-cheeked Honeyeater and White-fronted Honeyeater (Table 9).

The quail recorded in Table 9 as 'Quail (? sp.)' were sighted on two occasions on the slopes of Mount Manning Range. They were too large to be Little Button-quail, but could not be assigned to species. Painted Button-quail (*Turnix varia*) is the most likely species, but Stubble Quail (*Coturnix novaezeelandiae*) can not be ruled out.

Sixty-one species (25 non-passerine and 36 passerine) were recorded breeding during our visits (Table 9). Most breeding recorded was in spring 1980. A very large breeding colony of the Banded Stilt was discovered (Burbidge and Fuller 1983).

The quadrats were ordinated in 3-dimensional space using Semi-strong Hybrid Scaling (Belbin 1991), then a Minimum Spanning Tree (Belbin 1989) was superimposed (Figure 7). These analyses revealed a relationship between the composition of the passerine bird assemblages and surface lithology. Vegetation and lithology are closely correlated in the eastern Goldfields. Figure 7 shows a separation of saline (ME10), colluvial and alluvial plains (MM1, MM4, ME6), Quaternary sand sheets (ME8), Tertiary sands (MM5 and ME7), and the quadrats on or adjacent to outcrop surfaces (MM2, MM3 & ME9). Similar patterns were noted in other Goldfields Study Areas, eg, McKenzie *et al.* (1992).

Reptiles and Amphibians

Two frog and 53 reptile species were recorded in the Barlee–Menzies Study Area during our survey. The reptile species comprised 13 geckos, two legless lizards, nine dragons, 19 skinks, three monitors and seven snakes. These are listed in Table 11.

A search of the W.A. Museum collection and records from CALM's Goldfields Region faunal database revealed records of another four amphibian and six reptile species from the Study Area (Table 12). Thus, a minimum of five indigenous amphibian and 59 reptile species were extant in the Study Area at the time of European settlement.

The proportion of the known reptile species richness that we recorded from quadrats is listed in Table 3. Clearly, our survey methods were less effective for monitors and snakes. Similar biases in reptile sampling have been discussed by McKenzie *et al.* (1987).

Table 11 List of amphibians and reptiles recorded from the Barlee-Menzies Study Area indicating number of records in each amphibian and reptile quadrat during each sample period, together with opportunistic bird sightings near each Camp site. The three survey periods - winter (July-August 1979), spring (September 1980) and summer (March 1981) - are indicated in columns 1, 2 and 3 respectively for each surface type or camp site.

Vertebrate quadrat	MM[1]			MM1			MM2			MM3			MM4			MM5		
Vegetation quadrat				BM16			BM6			BM5			BM20			BM12		
Landform code				UN			HI			HI			V			S		
Lithological surface				Qc			Aiw			Aiw			Qz			Ts		
Drift fence nights				5	5	5	5	5	5	5	10	10	5	10	10	5	10	10
AMPHIBIA, MYOBATRACHIDAE																		
Neobatrachus wilsmorei																		
Neobatrachus sp.																		
Pseudophryne occidentalis																		
REPTILIA, GEKKONIDAE																		
Diplodactylus assimilis	x																	
Diplodactylus elderi	x																	
Diplodactylus granariensis granariensis			x	-	1	-							-	-	1			
Diplodactylus intermedius			x															
Diplodactylus pulcher										-	-	1					-	- 1
Diplodactylus vittatus	x																	
Gehyra purpurascens				-	-	1												
Gehyra variegata	x	x	x				-	1	-									
Heteronotia binoei	x	x	x				1	1	-	5	-	1						
Oedura reticulata				-	-	1												
Nephrurus vertebralis																		
Rhynchoedura ornata			x															
Underwoodisaurus millii			x															
PYGOPODIDAE																		
Delma butleri	x		x										-	-	1			
Lialis burtonis	x	x	x															
AGAMIDAE																		
Ctenophorus cristatus		x	x										-	-	1			
Ctenophorus fordi		x											-	2	2	1	3	-
Ctenophorus isolepis gularis			x															
Ctenophorus ornatus	x	x	x															
Ctenophorus reticulatus	x	x	x							-	1	-						
Ctenophorus salinarum																		
Ctenophorus scutulatus		x	x							-	-	1	-	1	-			
Moloch horridus			x															
Pogona minor	x			-	1	-												

1 Opportunistic records, not on quadrats; MM = Mount Manning Range Study Area, ME = Mount Elvire Study Area

ME[1]	ME6 MB21 V Qc 5 10 10	ME7 BM13 S Ts 10 10 10	ME8 BM23 V Qs 5 10 10	ME9 BM3 G Ag 5 5 5	ME10 BM10 L Qg 5 5 5	TOTAL
		- 1 -				- 1 -
x						
x						
		- - 2				- - 2
					- 1 -	- 2 1
x x				- - 1		- - 3
	- - 1					- - 2
x x	1 - 1	- - 1	- - 1	- 2 -		1 3 3
x x x				- 2 -		6 3 1
						- - 1
x x			- - 2			- - 2
x	- - 1					- - 1
x		2 - -				- 2 -
x						- - 1
x						1 5 2
x x						
x x x				1 2 2		1 3 2
x x x					2 3 1	2 3 1
x x	- 2 3		- - 1			- 3 5
x x						
x x			- - 1		- - 1	- 1 2

Table 11 (cont.)

Vertebrate quadrat	MM[1]			MM1			MM2			MM3			MM4			MM5		
Vegetation quadrat				BM16			BM6			BM5			BM20			BM12		
Landform code				UN			HI			HI			V			S		
Lithological surface				Qc			Aiw			Aiw			Qz			Ts		
Drift fence nights				5	5	5	5	5	5	5	10	10	5	10	10	5	10	10
SKINKIDAE																		
Cryptoblephalus carnabyi	x																	
Cryptoblepharus plagiocephalus	x	x											1	-	-			
Ctenotus atlas			x										-	-	1	-	-	1
Ctenotus leonhardii																		
Ctenotus mimetes																		
Ctenotus schomburgkii													2	-	-	-	1	2
Ctenotus uber uber			x				1	1	-									
Ctenotus xenopleura			x															
Cyclodomorphus branchialis	x	x	x															
Egernia depressa																		
Egernia formosa			x															
Egernia inornata				-														
Eremiascincus richardsonii			x															
Hemiergis initialis initialis	x	x	x															
Hemiergis millewae																		
Lerista macropisthopus macropisthopus	x									1	-	-						
Lerista muelleri	x	x	x							1	-	-	1	-	-	-	1	1
Menetia greyii	x									-	-	1	-	1	-	-	2	-
Morethia butleri	x	x																
VARANIDAE																		
Varanus caudolineatus																		
Varanus gouldii																-	-	1
Varanus tristis tristis				-	1	-												
TYPHLOPIDAE																		
Rhamphotyphlops hamatus		x																
ELAPIDAE																		
Demansia psammophis psammophis													-	1	-			
Pseudonaja modesta																		
Pseudonaja nuchalis																		
Rhinoplocephalus monachus																		
Vermicella bertholdi																		
Vermicella bimaculata																		
Total species/quadrat				-	3	2	2	3	-	3	1	4	3	4	4	1	4	5
Species richness	**33**			5			3			7			10			7		

1 Opportunistic records, not on quadrats; MM = Mount Manning Range Study Area, ME = Mount Elvire Study Area

ME[1]	ME6 MB21 V Qc 5 10 10	ME7 BM13 S Ts 10 10 10	ME8 BM23 V Qs 5 10 10	ME9 BM3 G Ag 5 5 5	ME10 BM10 L Qg 5 5 5	TOTAL
x x						1 - -
	- 1 -	- 1 2				- 2 4
x					- - 1	- - 1
x						
	- 2 1	- 3 1	- 1 -			2 7 4
						1 1 -
x						
	- - 1					- - 1
x						
x						1 - -
x x x	- - 2					2 1 3
			- 1 -		1 - -	1 4 1
x x			- - 1			- - 1
	- - 1		- 2 -			- 2 1
x	- - 1					- - 2
						- 1 -
						- 1 -
x						
x						
x			- - 1			- - 1
x						
x						
	1 3 9	1 3 4	- 3 6	1 3 2	2 2 3	
26	10	6	9	4	5	

Table 12 Amphibians and Reptiles known from the Barlee-Menzies Study Area, but not recorded during the survey.

Species	Specimen or source*	Location
Cyclorana maini	1	Mafia Dam
Neobatrachus kunapalari	R87408-14	Trainers Rocks
Neobatrachus pelobatoides	R113793	Mount Elvire Homestead
	R113794	Mount Elvire Station
Pseudophryne guentheri	R34127-34	80 km west of Diemals
Crenadactylus ocellatus ocellatus	R24897	Pigeon Rocks
Pygopodus lepidopodus lepidopodus	R52625	1 km south of Evanston mine
Caimanops aphiboluroides	R94404	Hospital Rocks
Ctenophorus maculatus griseus	R100223	46 km east-north-east of Karroun Hill
Ctenotus severus	R12533	Pigeon Rocks
	R87404	Croobenyer Rockhole
Lerista picturata	R66287	Riverina

* 1=CALM Goldfields Region reserve fauna recording system, 13 May 1992; numbers commencing with an 'R' are registration numbers of specimens lodged at Western Australian Museum

The reptile list from the Study Area (53 species) compares with the 55 species known from the Jackson–Kalgoorlie Study Area to the south (Dell and How 1985), the 43 species recorded from the Youanmi–Leonora Study Area to the north (Dell and How 1992) and the 67 recorded from the Edjudina–Menzies Study Area to the east (Dell and How 1988).

Although they have not actually been recorded within the Study Area, at least another four lizard and six snake species might be expected on the basis of their known distributions in Western Australia: *Diplodactylus maini*, *D. squarrosus*, *Lerista gerrardii*, *Tiliqua occipitalis*,

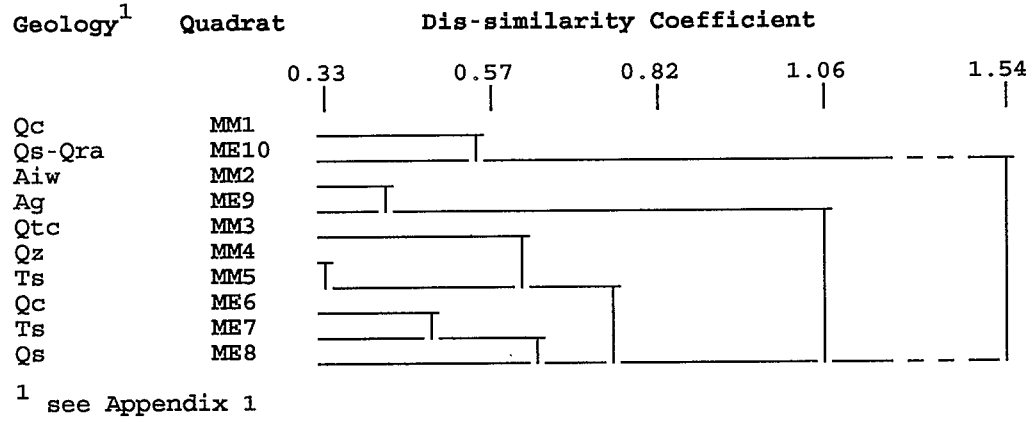


Figure 8 Reptile quadrats classified according to similarities in their species composition using the Czekanowski (1932) similarity algorithm and unweighted pair-group mean averaging (UPGMA) as a sorting strategy (Belbin 1989).

Table 13 Additional reptiles recorded on vertebrate quadrats during September 1994 at the Mount Elvire Survey Area.

Species	ME6	ME7	ME8	ME9	ME10
Nephrurus vertebralis				x	
Rhynchoedura ornata		x	x		
Pogona minor		x			
Cryptoblepharus carnabyi			x		
Egernia inornata		x	x		
Lerista muelleri			x		
Menetia greyii		x		x	
Morethia butleri	x				
Vermicella bertholdi	x				

Aspidites ramsayi, *Morelia stimsoni*, *Denisonia fasciata*, *Furina ornata*, *Pseudechis australis* and *Simoselaps semifasciatus*.

A total of 10 reptile species were recorded on each of the two richest quadrats (MM4 and ME6: Table 11). These were both on Quaternary Valley landforms with sandy soils. The most species poor quadrat, with three species, was MM2, on the slope of Mount Manning Range. As discussed above (Mammals) this quadrat could not be pit trapped and its apparent low number of reptiles may be an artefact of our methodology. Overall we recorded a mean of 6.6 species / quadrat. Quadrats on equivalent surfaces in adjacent Study Areas were richer in species (see, e.g., Table 7 in Dell & How 1985), implying that more prolonged sessions of sampling would reveal the presence of additional species on quadrats, particularly litter-dwelling and fossorial skinks. The shape of the reptile accumulation curves, discussed above, is consistent with this view.

Nevertheless, when the sites were classified in terms of their lizard species composition (excluding Varanids and Pygopodids) certain patterns emerged (Figure 8). The two outcrop surfaces (MM2 & ME9) cluster, as do the three sandy surfaces at the Mt Manning survey area (MM3, MM4 & MM5). Sandy surfaces, both Quaternary and Tertiary, at the Mt Elvire survey area also cluster, even though ME6 is only superficially sandy (see Appendix 1).

The under-sampling apparent in reptiles from some quadrats was subsequently offset by further survey work in September 1994. At this time each quadrat in the Mount Elvire Survey Area was sampled by 10 drift fence nights of trapping. As well, some quadrats were subjected to limited searching. Additional species recorded on the quadrats are listed in Table 13. No species was added to the lists for the Barlee–Menzies Study Area or Mount Elvire Survey Area.

REFERENCES

Austin, M.P. (1984). Problems of vegetation analysis for nature conservation. In: "Survey Methods for Nature Conservation". (eds: K. Myers, C.R. Margules and I. Musto) Vol. 1, pp 101–130. CSIRO Division of Water and Land Resources, Canberra.

Belbin, L. (1989). PATN user's guide. CSIRO Division of Wildlife and Ecology, Canberra.

Belbin, L. (1991). Semi-strong Hybrid Scaling: a new ordination algorithm. *J. Veg. Sci.* **2**(4), 491–496.

Biological Surveys Committee of Western Australia (1984). The Biological Survey of the Eastern Goldfields. Part I: Introduction and Methods. *Rec. West. Aust. Mus.* Supplement No. **18**, 1–19.

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Royal Australasian Ornithologists Union. Melbourne University Press, Carlton.

Braithwaite, R.W., Morton, S.R., Burbidge, A.A. & Calaby, J.H. (in press). Australian names for Australian rodents. CSIRO Division of Wildlife & Ecology, Canberra.

Burbidge, A.A. and Fuller, P.J. (1983). Banded Stilt breeding at Lake Barlee, Western Australia. *Emu* **82**, 212–216.

Burbidge, A.A. and McKenzie, N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation considerations. *Biological Conservation* **50**, 143–198.

CALM (1992). Goldfields Region: draft regional management plan. Department of Conservation and Land Management, Perth.

Czekanowski, J. (1932). Coefficient of racial likeness, und durschschnittliche differenz. *Anthrop. ANZ.* **9**, 227–249.

Dell, J. and How, R.A. (1985). Vertebrate Fauna. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 3: Jackson–Kalgoorlie Study Area. *Rec. West. Aust. Mus.* Supplement No. **23**, 39–66.

Dell, J. & How, R.A. (1988). Vertebrate fauna. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 5: Edjudina–Menzies Study Area. *Rec. West. Aust. Mus.* Supplement No. **31**, 38–66.

Dell, J. & How, R.A. (1992). Vertebrate fauna. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 6: Youanmi–Leonora Study Area. *Rec. West. Aust. Mus.* Supplement No. **40**, 20–32.

Henry-Hall, N.J. (1990). *Nature conservation reserves in the Eastern Goldfields, Western Australia (southern two-thirds of CTRC System 11).* Unpublished report submitted to the EPA Red Book Task Force. Environmental Protection Authority, Perth, Western Australia.

McKenzie, N.L. (1984). Biological surveys for nature conservation by the Western Australian Department of Fisheries and Wildlife: A current view. In: Survey Methods for Nature Conservation. (eds: K. Myers, C.R. Margules and I. Musto). Vol. 2, pp 88–117. CSIRO Division of Water and Land Resources, Canberra.

McKenzie, N.L., Rolfe, J.K. and Carter, D. (1987). Reptiles and Amphibians. In: A Biological Survey of the Nullarbor Region, Australia. (eds: N.L. McKenzie and A.C. Robinson). pp 179–210. South Australian Department of Environment and Planning, Adelaide.

McKenzie, N.L., Robinson, A.C. and Belbin, D.L. (1991a). "Biogeographic survey of the Nullarbor district, Australia". Pp 109–126. In: Nature Conservation: Cost Effective Biological Surveys and Data Analysis. (eds: Margules, C.R. & Austin, M.P). CSIRO Division of Wildlife and Ecology, Canberra.

McKenzie, N.L., Belbin, L., Keighery, G.J. and Kenneally, K.F. (1991b). Kimberley rainforest communities: patterns of species composition and Holocene biogeography. In: Kimberley Rainforests. (Eds: N.L. McKenzie, R.B. Johnston & P.G. Kendrick). Surrey Beatty & Sons, New South Wales.

McKenzie, N.L., Rolfe, J.K. and Youngson, W.K. (1992). Vertebrate fauna. In: The Biological Survey of the Eastern Goldfields of Western Australia. Part 8. The Kurnalpi – Kalgoorlie Study Area. *Rec. West. Aust. Mus.* Supplement No. **41**, 37–64.

Rosenweig, M.L. & Abramsky, Z. (1985). Detecting density-dependent habitat selection. *Amer. Nat.* **126**, 405–417.

Storr, G.M. (1985). Birds of the Mid-eastern Interior of Western Australia. Rec. West. Aust. Mus. Supplement No. **22**.

Walker, I.W. and Blight, D.F. (1983). *Barlee, Western Australia. 1:250,000 Geological Series, Sheet SH/50–8, map and explanatory notes.* Geological Survey of Western Australia. Department of Mines, Western Australia.

ACKNOWLEDGEMENTS

We thank Jim Rolfe for assistance with the field sampling program, for compiling databases and preparing Figures 4, 5, 6 & 7, Alan Clarke for preparing Figure 2 and Ken Cashin for helping in the field.

We are grateful to the Western Australian Herbarium for making available facilities generally, and to K.F. Kenneally and members of the technical staff for aiding the processing of the specimens. Assistance with the identification of the plants was provided by T.E.H. Aplin, M.I.H. Brooker, R. Carolin, R.J. Chinnock, B.J. Conn, D.A. Cooke, H.J. Eichler, J.W. Green, H.J. Hewson, S.D. Hopper, K.F. Kenneally, N.S. Lander, D.J. McGillivray, T.D. Mcfarlane, N.G. Marchant, B.R. Maslin, G. Perry, B.L. Rye, P.S. Short, H.R. Toelken, M. Trudgen, J.G. West, P. Weston and P.G. Wilson.

We record our appreciation to the Director and staff of the W.A. Museum for their assistance with identification and curation of the vertebrate specimens. In particular, K. Aplin, N. Cooper, J. Henry, D.J. Kitchener and L.A. Smith.

Data collected during the 1994 *Landscope* Expedition 'A biological survey of Mount Elvire' are reported in Table 13. We thank Andrew Chapman and the Expedition participants for their help.

The Australian Bureau of Meteorology, Perth, provided the climatic data.