

Terrestrial bird assemblages of the semi-arid woodlands and *Acacia* sandplains in the southern rangelands of Western Australia

JACQUELINE D RICHARDS¹, NEIL HAMILTON², PHIL J FULLER²,
DAVE ALGAR² AND JANE PRINCE³

¹Australian Wildlife Conservancy, PO Box 8070, Subiaco East, Western Australia 6008
jacqueline.richards@bigpond.com

²Department of Environment and Conservation, PO Box 51, Wanneroo, Western Australia 6065
neil.hamilton@dec.wa.gov.au

³School of Animal Biology, University of Western Australia, 35 Stirling Hwy, Crawley, Western Australia 6009
jprince@cyllene.uwa.edu.au

ABSTRACT

As part of a broader study involving the control of introduced predators, the seasonal presence of avian fauna was monitored in winter and spring during 2006 and 2007 at two study sites. The two sites, Mt Gibson Wildlife Sanctuary and Karara–Lochada Pastoral Stations, are located in the semi-arid *Eucalyptus* woodlands and *Acacia* shrublands within the Avon–Wheatbelt and Yalgoo bioregions of Western Australia. Sixty-eight bird species were recorded at Mt Gibson Wildlife Sanctuary and 60 species at Karara–Lochada Pastoral Stations; 94 species in total at the two sites. Bird species were recorded at 24 quadrats within four land system types represented at each of the study sites. Fifty-one of the species were present at both sites while 17 occurred only at Mt Gibson and nine only at Karara–Lochada, despite apparently similar habitat at the two locations. Opportunistic records of nesting species were also recorded.

Keywords: avian, conservation, pastoral, predator control, survey, wheatbelt.

INTRODUCTION

The Australian Wildlife Conservancy (AWC) and Department of Environment and Conservation (DEC), in partnership with the Invasive Animals Co-operative Research Centre (IA CRC), commenced a project in 2006 to investigate techniques for the sustained control of introduced predators in the southern rangelands of Western Australia (Richards & Algar 2008). At the treatment site, AWC's Mt Gibson Wildlife Sanctuary, a strategy for the control of introduced predators was implemented. At the control site nearby, DEC's Karara–Lochada Pastoral Stations, which has a similar suite of land system types, introduced predators were not controlled.

As part of this broader project to control the feral cat (*Felis catus*), fox (*Vulpes vulpes*) and wild dog (*Canis familiaris*), the abundance of their prey items (small mammals, reptiles, birds and invertebrates) was monitored at both sites within the semi-arid *Eucalyptus* woodlands and sandplains dominated by *Acacia* shrublands. These vegetation types characterize the semi-arid southern

rangelands to the north of the wheatbelt zone in Western Australia. Other results of the broader project will be reported elsewhere, including papers within the same volume of this journal.

Bird fauna in the region has been documented after a number of unpublished, small-scale surveys conducted in association with mining companies (and other organizations such as DEC, AWC and Bush Heritage Australia) for particular reserves within the region and surrounding areas. In particular, information on bird species assemblages has been provided by DEC and the Western Australian Museum for areas to the north (Carnarvon Basin; Burbidge et al. 2000), east (Goldfields; Burbidge et al. 1995), south (Wheatbelt; e.g. Dell et al. 1979; Kitchener et al. 1979) and west (vacant Crown Land at White Wells; Burbidge et al. 1989).

In this paper we document the bird species assemblages in 24 quadrats at two study sites (Mt Gibson Wildlife Sanctuary and Karara–Lochada Pastoral Stations) within the semi-arid southern rangelands immediately to the north of the wheatbelt zone in Western Australia, and describe how the composition of these assemblages varies across land system types within and between the properties.

METHODS

Mt Gibson Wildlife Sanctuary Study Site

Mt Gibson Wildlife Sanctuary is located approximately half way between Wubin and Paynes Find in Western Australia ($29^{\circ} 36' 36.2''$ S, $117^{\circ} 24' 31.3''$ E; Fig. 1) and covers an area of 130,500 ha straddling the boundary between the South-West and Eremaean Botanical Provinces. The area has a semi-arid climate with hot dry summers and mild wet winters. Summer temperatures range from 19–36 °C, and winter temperatures from 6–18 °C. There are typically 9–11 months of dry weather, with an annual rainfall of 343 mm (Bureau of Meteorology records 1983 to 2007), which arrives as gentle soaking rains and thundery showers in winter or in summer as occasional tropical cyclones or rain bearing depressions. Evapotranspiration rates are considerably higher than rainfall with the annual average for the Paynes Find region being 2,480 mm.

Mt Gibson Wildlife Sanctuary is characterized by mixed *Acacia* shrublands on sandplain and York Gum (*Eucalyptus loxophleba*), Salmon Gum (*E. salmonophloia*) and Gimlet (*E. salubris*) woodlands. The sanctuary contains 13 vegetation associations (Beard 1976). The dominant landforms are greenstone ranges in the north-east and banded ironstone formations to the north-west. Granites and gneisses of the Yilgarn Block underlie much of the area and outcrop as domes or breakaways (McKenzie & May 2003). The ranges are separated by gently sloping pediments and flood plains upslope from salt lakes and clay pans (McKenzie & May 2003). Sand plains occur extensively to the south.

Drainage is internal and disorganized, and an extensive salt lake, Lake Moore, bounds Mt Gibson Wildlife Sanctuary to the east.

The Mt Gibson Pastoral Lease was granted in 1878 to graze sheep (*Ovis aries*) and has had a long history of pastoralism. The private, not for profit, conservation organization AWC acquired the lease in 2001, which had been managed conservatively for the preceding 20 years to promote environmental values. The lease was subsequently destocked, removing most sheep and goats (*Capra hircus*) and leaving a small resident flock of goats to satisfy Pastoral Lands Board requirements. Fox control was conducted in 2004 and 2005 by AWC using 1080 dried meat baits laid by hand throughout the pastoral lease. Prior to this, minimal predator control activities had been conducted by neighbouring pastoral lessees in an ad hoc manner and mostly directed towards baiting of wild dogs. Mt Gibson was chosen as a 'treatment' site, where introduced predators were controlled with an annual aerial baiting of 70,000 'Eradicat' baits over the entire pastoral lease in July 2006 and August 2007 in a collaborative effort between AWC, DEC and the IA CRC (Richards & Algar 2008).

Karara–Lochada Study Site

Karara ($29^{\circ} 14' 21''$ S, $116^{\circ} 43' 44''$ E) and Lochada ($29^{\circ} 12' 60''$ S, $116^{\circ} 33' 60''$ E) are adjacent reclaimed pastoral leases managed by DEC and located 86 km north-west of Mt Gibson Wildlife Sanctuary and 50 km east of Morawa, and cover an area of 109,300 and 114,600 ha respectively (Fig. 1). The average annual rainfall recorded for Karara is 312.3 mm (Bureau of Meteorology, based on records



Figure 1. Location of Karara–Lochada Pastoral Stations (left) and Mt Gibson Wildlife Sanctuary (right) in the southern rangelands region of Western Australia, and the 24 quadrats described in this study: YS—yellow sandplains; OP—Olympic plains; GR—granite; SL—salt lake; the numerals 1 to 4 denote quadrat replicates within each land system.

1928–1939 and 1992–2008) and for Lochada is 327 mm (Bureau of Meteorology, based on records 1911–1939).

The climate, landforms, land systems and vegetation associations within the Karara–Lochada Pastoral Leases are similar to those found on Mt Gibson. Karara–Lochada also lies on the interface between the South West Botanical Province and the Eremaean Botanical Province, and mainly lies within the Yalgoo bioregion. There are at least 14 land types (Van Vreeswyk & Godden 1998) and 14 vegetation types (Beard 1976) on Karara–Lochada. The area is characterized by mixed *Acacia* shrublands on sandplain and sparse York Gum woodlands. The stations lie within the Yilgarn craton and across the boundaries of the Murchison Plateau and the Salinaland Plateau, with frequent granite rises and low domes.

The pastoral leases have historically run Merino sheep and feral goats have been mustered and sold in recent years. Lochada Pastoral Station was purchased by DEC in 2000 and Karara Pastoral Station in 2002. Both were subsequently destocked for conservation purposes. Karara–Lochada was chosen as the ‘control’ site, where introduced predators were not baited. Minimal predator control had been conducted on the pastoral leases prior to this study, and was mostly undertaken by neighbouring pastoral lessees in an ad hoc manner to bait wild dogs.

Bird Surveys

Twelve quadrats were selected at each site, including three within each of four habitat or ‘land system’ types (Department of Agriculture and Food Western Australia; DAFWA 1990) characteristic of both Karara–Lochada and Mount Gibson: 1) Joseph (YS; yellow sandplains)—undulating yellow sandplains supporting dense mixed *Acacia* shrublands; 2) Pindar (OP; Olympic plains)—red loamy sandplain supporting *Eucalyptus* woodlands and *Acacia* shrublands; 3) Euchre (GR; granite)—low granite breakaways with alluvial plains and sandy tracts supporting *Eucalyptus* woodlands and *Acacia* shrublands with patchy mallees on granitic breakaways; and 4) Carnegie (SL; salt lake)—salt lakes with fringing saline plains, dunes and sandy banks. The quadrats of approximately 16 ha were located adjacent to vehicle tracks for easy access (Fig. 1).

Bird surveys were conducted twice each year for two years in each of the 24 quadrats: in winter (20–24 June 2006, 11–15 July 2007 at Mt Gibson and 26–30 June 2006, 6–10 July 2007 at Karara–Lochada), just prior to predator baiting to assess potential prey abundance at its lowest; and in spring (25–29 September 2006, 3–7 October 2007 at Mt Gibson and 19–23 September 2006, 23–27 September 2007 at Karara–Lochada), when bird populations had received an influx of new recruits immediately after breeding. Each quadrat was sampled for an hour immediately following dawn and an hour prior to dusk in each sampling period with a single observer walking a random route through the quadrat, checking all micro-habitats, following up calls and locating as many birds as possible, while ensuring that the entire 16 ha were covered systematically. The objective of sampling was to determine species presence/absence at each quadrat. No

effort was made to estimate abundance of species. Bird species names and taxon order were taken from Christidis and Boles (2008). Scientific names are listed in Appendix 1.

Statistical Analyses

The bird assemblage data were analysed by a permutational multivariate repeated measures analysis of variance (PERMANOVA) with two fixed, orthogonal, between-site factors:

- station (two levels—Mt Gibson [MG] and Karara–Lochada [KL]),
- land system (four levels—YS, OP, GR and SL);

and one fixed, within-site factor:

- year (two levels—2006 and 2007),

using the PERMANOVA+ add-on to the PRIMER-E software package (Anderson et al. 2008). Because the data were presence/absence, rather than abundance, no transformation was required. Pairwise similarities between all sites were estimated by the Bray–Curtis similarity coefficient.

Canonical Analysis of Principal Coordinates, or CAP analysis (Anderson & Willis 2003) was used to find the axes best capable of discriminating between the station–land system and station–year combinations of sites. The visual display of sites on these axes was overlaid with species vectors, indicating the strength and the direction of the Spearman rank correlation between those species and the CAP axes (Anderson et al. 2008). The identity of the species contributing the most to the separation of levels within significant factors was determined with the SIMPER routine within PRIMER-E.

Opportunistic Sightings

En route to the quadrats, opportunistic sightings were also recorded during bird survey periods. Details of species sighted, habitat and nesting biology were recorded and collated in order to add to the knowledge of distribution and natural history, particularly for species for which general biological knowledge is minimal.

RESULTS

Bird Surveys

A total of 94 bird species (58 passerines and 36 non-passerines) was recorded during the four bird survey periods at Mt Gibson and Karara–Lochada Pastoral Stations in the 24 quadrats and as opportunistic sightings (Appendix 1). Sixty-eight species were recorded at Mt Gibson Wildlife Sanctuary and 60 species at Karara–Lochada Pastoral Stations (Table 1). Of these species, 51 were found at both Mt Gibson and Karara–Lochada.

Nine bird species were recorded once only at Karara–Lochada during the survey periods: Peregrine Falcon, Little Corella, Mulga Parrot, Pallid Cuckoo, White-winged

Fairy-wren, Grey-fronted Honeyeater, Varied Sittella, Torresian Crow and Welcome Swallow. Similarly, 17 species were recorded once only at Mt Gibson during the survey periods: Spotted Nightjar, Brown Goshawk, Australian Hobby, Western Corella, Cockatiel, Black-eared Cuckoo, Rainbow Bee-eater, White-eared Honeyeater, Brown-headed Honeyeater, Black-faced Woodswallow, Magpie-Lark, Hooded Robin, Southern Scrub-robin,

Rufous Songlark, White-backed Swallow and Tree Martin. Sixteen species were recorded at a single site only. Twenty-one species were recorded at >50% of sites, and 10 species were recorded at >80% of sites (Table 2).

Table 1

Number of bird species recorded at Mt Gibson and Karara–Lochada during the four survey periods, including opportunistic sightings.

Survey period	Mt Gibson	Karara–Lochada
June 2006	58	56
September 2006	54	40
July 2007	53	47
September/October 2007	48	67

Table 2

Frequency of occurrence of the most commonly encountered bird species in the 24 quadrats sampled at Mt Gibson and Karara–Lochada.

Species	No. of quadrats	Percent
Australian Ringneck	23	96
Crested Bellbird	23	96
Red-capped Robin	23	96
Inland Thornbill	22	92
Chestnut-rumped Thornbill	22	92
Spiny-cheeked Honeyeater	22	92
Singing Honeyeater	21	88
Grey Butcherbird	20	83
Grey Shrike-thrush	20	83
Rufous Whistler	20	83
Redthroat	19	79
Galah	18	75
Black-faced Cuckoo-shrike	17	71
Australian Raven	17	71
Common Bronzewing	17	71
White-fronted Honeyeater	17	71
Pied Butcherbird	14	58
Splendid Fairy-wren	13	54
Red-tailed Black-Cockatoo	12	50
Weebill	12	50
Yellow-throated Miner	12	50

Table 3

Results of the PERMANOVA of the effect of station, land system and year on the structure of bird assemblages at Mt Gibson and Karara–Lochada.

Source	df	Mean Square	Pseudo-F	p	# permutations
Station	1	2714.5	2.1227	0.0366	4976
Landsystem	3	3786.8	2.9612	0.0002	4978
Station x landsystem	3	2260.1	1.7674	0.0142	4974
Site(Station x Landsystem)	16	1278.8			
Year	1	5867.9	5.0746	0.0002	4989
Station x year	1	2122.3	1.8354	0.0888	4986
Landsystem x year	3	1214.6	1.0504	0.3998	4968
Station x landsystem x year	3	1680.0	1.4528	0.0958	4971
Residual	16	1156.3			

Statistical Analyses

Bird assemblage structure was significantly different between stations, land systems and years (Table 3). There was also a significant interaction between stations and land systems. Pairwise post-hoc comparisons of stations within each land system showed that assemblages were only different in the OP and SL land systems, while comparisons of land systems within each station showed that at Mt Gibson, assemblages in OP and YS land systems were different from those in SL. At Karara–Lochada, assemblages in OP and YS were significantly different. All other pairwise comparisons were not significantly different.

Redthroats, Singing Honeyeaters, White-fronted Honeyeaters, Rufous Whistlers and Red-capped Robins were more commonly sighted at Mt Gibson, while Galahs were more common at Karara–Lochada. These six species explained 20% of the difference in assemblage structure between stations. From 2006 to 2007, there was a general increase in the sightings of Common Bronzewings, Galahs, Black-faced Cuckoo-shrikes, corvids and Red-capped Robins, and a decrease in sightings of White-fronted Honeyeaters, which together explained 25% of the difference in assemblage structure.

This is further illustrated by the separation of sites by year on the first two CAP axes (Fig. 2), which had correlations of 0.87 and 0.7, respectively, with the separation of the four station–year groups classifying 60% of the sites into their correct station–year groups. Increasing numbers of Red-capped Robins, corvids and Common Bronzewings were highly correlated with the first CAP axis, which effectively separated the two years.

The differences in species composition between land systems were considered separately at each station (Table 4). At Mt Gibson, sightings of Southern Whiteface in the SL land system separated SL assemblages from those in other land systems. At Karara–Lochada, the sightings of Splendid Fairy-wrens and Yellow-throated Miners in the OP land system differentiated OP assemblages from the

Table 4

Average similarity of the assemblages within and between land systems at (a) Mt Gibson and (b) Karara–Lochada. For each pairwise comparison, the species contributing the most to the **similarity** of sites within land systems (diagonal) or the **differentiation** of sites between land systems (off-diagonal) are given. Species in bold indicate they are at a greater abundance in the land system heading the column.

a) Mt Gibson				
	GR	YS	OP	SL
GR	50.5% Australian Ringneck Crested Bellbird			
YS	47.63% Common Bronzewing Weebill	44.5% Australian Ringneck Crested Bellbird		
OP	36.4% Weebill Black-faced Cuckoo-shrike	42.6% Common Bronzewing Grey Butcherbird	48.1% Australian Ringneck Crested Bellbird	
SL	50.1% Pied Butcherbird Southern Whiteface	45.7% Pied Butcherbird Southern Whiteface	48.6% Weebill White-fronted Honeyeater	68.9% Australian Ringneck Inland Thornbill
b) Karara-Lochada				
	GR	YS	OP	SL
GR	39.3% Chestnut-rumped Thornbill Spiny-cheeked Honeyeater			
YS	45.1% White-browed Babbler Grey Butcherbird	52.4% Chestnut-rumped Thornbill Crested Bellbird		
OP	46.0% Splendid Fairy-wren Yellow-throated Miner	53.1% Splendid Fairy-wren Yellow-throated Miner	60.4% Australian Ringneck Inland Thornbill	
SL	29.5% Chestnut-rumped Thornbill White-browed Babbler	35.0% Redthroat Rufous Whistler Grey Shrike-thrush	35.4% Splendid Fairy-wren Redthroat	34.8% Red-tailed Black-cockatoo Australian Ringneck

other three, while Redthroats and Grey Shrike-thrush in the YS land system differentiated it from the SL land system.

These results suggest very specific patterns of station by land system assemblages, rather than general land system assemblages consistent across stations. Despite this, CAP analyses did not result in clear separation of station – land system groups (Fig. 3), classifying only 45% of sites into their correct groupings, even though correlations between the first two CAP axes and the separation were strong (0.87 and 0.83, respectively).

Opportunistic Sightings

An additional 17 bird species were recorded during the survey period as opportunistic sightings away from the 24 survey quadrats within the Mt Gibson and Karara–Lochada Pastoral Stations (Appendix 1).

Some bird species were found within particular landsystem types:

- 1 Joseph—Emu, Malleefowl, Wedge-tailed Eagle, Brown Falcon, Splendid Fairy-wren, White-fronted Honeyeater, Black-faced Woodswallow, White-

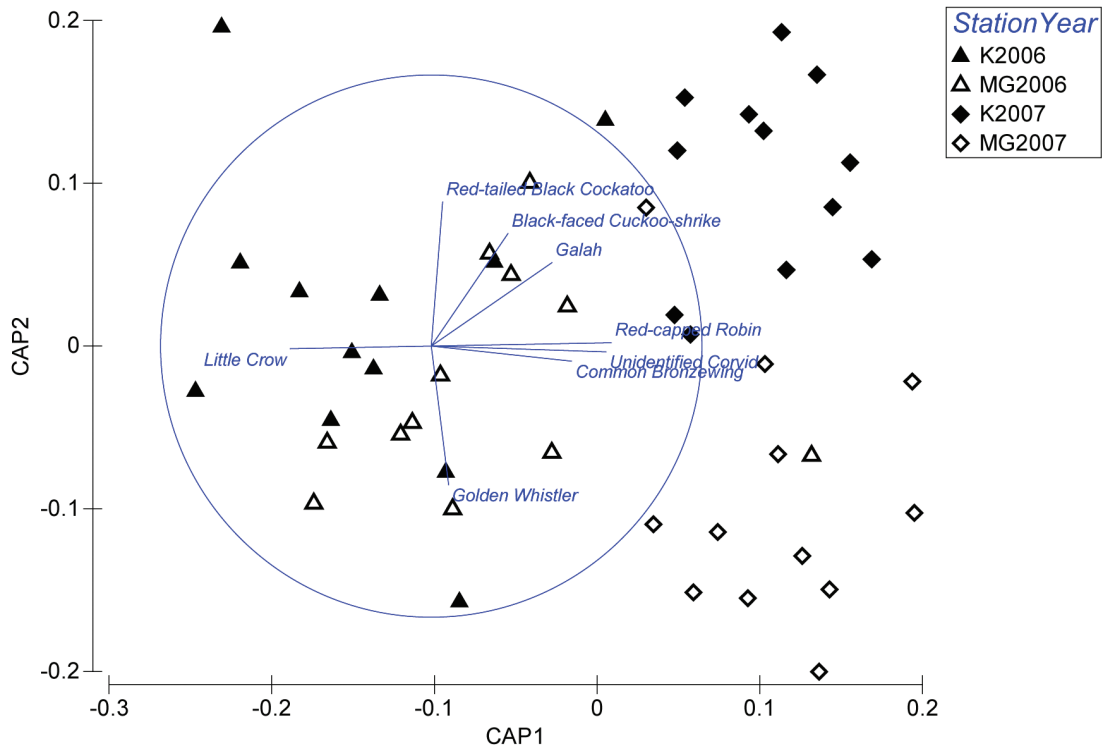


Figure 2. Separation of sites by station and year by Canonical Analysis of Principal Coordinates. Vectors show the direction of the contribution of some of the species with the highest Spearman rank correlations to the CAP axes. MG: Mt Gibson, KL: Karara–Lochada Pastoral Stations.

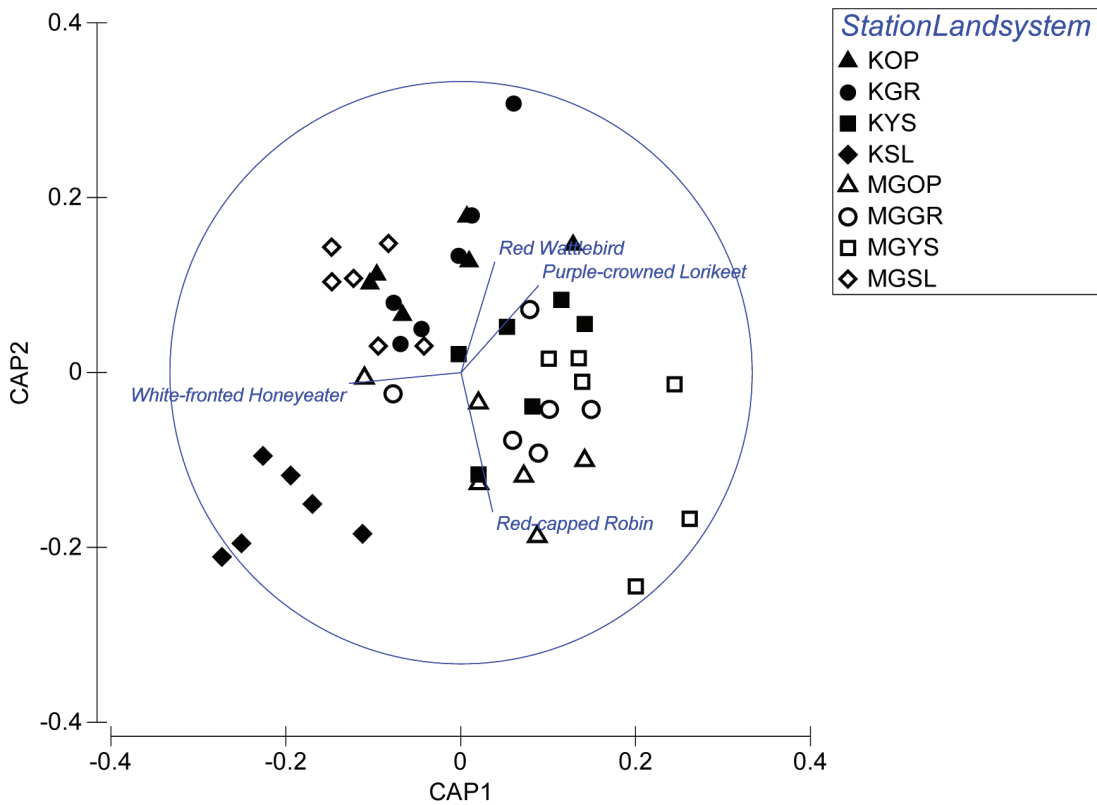


Figure 3. Separation of sites by station and land system by Canonical Analysis of Principal Coordinates. Vectors show the direction of the contribution of some of the species with the highest Spearman rank correlations with the CAP axes. MG: Mt Gibson, KL: Karara–Lochada Pastoral Stations; GR: Euchre, OP: Pindar, SL: Carnegie, YS: Joseph land systems.

backed Swallow (nesting in a disused yellow sand pit).

- 2 Pindar—Emu, Malleefowl, Wedge-tailed Eagle, Brown Falcon, Red-tailed Black-Cockatoo, Galah, Western Corella, Purple-crowned Lorikeet, Regent Parrot, Australian Ringneck, Mulga Parrot, Weebill, Chestnut-rumped Thornbill, Striated Pardalote, White-browed Babbler, Crested Bellbird, Black-faced Wood Swallow, Willie Wagtail, Black-faced Cuckoo-shrike, Tree Martin.
- 3 Euchre—Emu, Malleefowl, Common Bronzewing, Splendid Fairy-wren, Weebill, Yellow-rumped Thornbill, Chestnut Quail-thrush, Grey Shrike-thrush, Crested Bellbird, Red-capped Robin.
- 4 Carnegie—Emu, Splendid Fairy-wren, White-winged Fairy-wren.

A number of species were found nesting around the homesteads and associated buildings, including Crested Pigeon, Banded Lapwing, Galah, Australian Ringneck, Welcome Swallow and Zebra Finch.

DISCUSSION

Bird Assemblages of Mt Gibson and Karara–Lochada

The Mt Gibson and Karara–Lochada region possess elements of both the South West and Eremaean Botanical Provinces, with a blend of south-west and arid zone vegetation assemblages characteristic of the Yalgoo, Avon Wheatbelt and Murchison IBRA bioregions, and their associated faunal species.

Ninety-four species of bird were recorded at Mt Gibson Wildlife Sanctuary and Karara–Lochada Pastoral Stations in 2006 and 2007 over four survey periods during winter and spring. The most common and widespread species were the Australian Ringneck, Chestnut-rumped Thornbill, Inland Thornbill, Singing Honeyeater, Spiny-cheeked Honeyeater, Grey Shrike-thrush, Crested Bellbird, Grey Butcherbird and Red-capped Robin. The species are common throughout the southern rangelands and northern wheatbelt regions. A previous survey of vacant crown land at White Wells immediately to the south-west of Mt Gibson recorded 60 bird species (26 non-passerines, 34 passerines; Burbidge et al. 1989), 56 of which were recorded in this study.

The area is an important repository for a number of threatened bird species or species suffering some impact and formerly widely distributed across southern Western Australia, but now uncommon or confined to remnant areas of wheatbelt *Eucalyptus* woodland (Barrett et al. 2003). These species recorded during the surveys included Malleefowl, Square-tailed Kite, Peregrine Falcon, Shy Heathwren, Redthroat, Chestnut Quail-thrush and Hooded Robin.

Equally significant as nesting areas was the importance of species' requirements in a variety of landforms to suit individual needs. For example, members of the

Psittaciformes (parrot families) were observed flying from nesting sites within *Eucalyptus* woodland to feed in the other three landform systems sampled during the study. The Salmon gum and York gum woodlands were particularly important areas for many hollow-nesting birds, such as Red-tailed Black-Cockatoo, Major Mitchell's Cockatoo, Galah, Western and Little Corellas, Cockatiel, Purple-crowned Lorikeet (during periods when *Eucalyptus* were flowering only), Regent Parrot, Australian Ringneck and Mulga Parrot. Elegant Parrots were sighted after the surveys on Karara Station; they may also have been using the woodland areas (Burbidge et al. 1989). Many of these species have declined in abundance through vegetation clearing in the wheatbelt and habitat degradation (Barrett et al. 2003; Saunders et al. 1985; Saunders & Ingram 1995).

Land System Bird Associations

There were no obvious patterns in bird assemblages across land systems and stations. Specific bird assemblages were associated with land system types at Mt Gibson and Karara–Lochada, however the delineation of these assemblages was not clear with the two years of presence/absence data collected. Redthroats, Singing Honeyeaters, White-fronted Honeyeaters, Rufous Whistlers and Red-capped Robins were more commonly sighted at Mt Gibson, while Galahs were more common at Karara–Lochada. Karara–Lochada has a more recent and intensive pastoral history than Mt Gibson and Galahs are recognized as a disturbance specialist.

Changes between Years

Between years, there was a general increase in the sightings of Common Bronzewing, Galahs, Black-faced Cuckoo-shrikes, corvids and Red-capped Robins, and a decrease in sightings of White-fronted Honeyeaters. Reasons for this increase are unclear.

CONCLUSIONS

The survey of bird species presence at Mt Gibson Wildlife Sanctuary and Karara–Lochada Pastoral Stations over a period of two years in two seasons has provided information of the bird assemblages present in the semi-arid *Eucalyptus* woodlands and *Acacia* shrublands of the northern wheatbelt and southern rangelands of Western Australia. Additional data will become available over the next few years as Birds Australia (Western Australia) will continue the bird surveys on Mt Gibson Wildlife Sanctuary.

ACKNOWLEDGEMENTS

Funding was provided by the Invasive Animals Cooperative Research Centre, the Department of Environment and Conservation and Australian Wildlife Conservancy. We would like to thank Craig Stephens, manager of Mt Gibson Wildlife Sanctuary, and Peter and

Julie Woodhead from DEC, managers of Karara Pastoral Station, for logistical support during field surveys. AWC volunteer Maree Weirheim assisted with two survey periods at Mt Gibson Wildlife Sanctuary. Blair Parsons from AWC assisted with map production. We thank Allan Burbidge and Blair Parsons for their comments on earlier drafts of the manuscript.

REFERENCES

- Anderson MJ, Willis TJ (2003) Canonical analysis of principle coordinates: a useful method of constrained ordination for ecology. *Ecology* **84**, 511–525.
- Anderson MJ, Gorley RN, Clarke KR (2008) *PERMANOVA + for PRIMER: Guide to Software and Statistical Methods*. PRIMER-E, Plymouth, UK.
- Barrett GW, Silcocks A, Barry S, Cunningham R, Poulter R (2003) *The New Atlas of Australian Birds*. Birds Australia, Hawthorn East, Victoria.
- Beard JS (1976) *The Vegetation of the Perenjori Area, Western Australia: Map and Explanatory Memoir 1:250,000 Series*. Vegmap Publications, Perth.
- Burbidge AA, Dixon, KW, Fuller PJ (1989) *The Flora and Fauna of Vacant Crown Land at White Well, Shire of Dalwallinu, Western Australia*. Technical Report No 24. Department of Conservation and Land Management.
- Burbidge AH, Fuller PJ, McKenzie NL (1995) Vertebrate fauna. In *The Biological Survey of the Eastern Goldfields of Western Australia. Part 12. Barlee–Menzies Study Area* (eds GJ Keighery, NL McKenzie, NJ Hall). *Records of the Western Australian Museum Supplement* **49**, 208–245.
- Burbidge AH, Johnstone RE, Fuller PJ, Stone P (2000) Terrestrial birds of the southern Carnarvon Basin, Western Australia: contemporary patterns of occurrence. *Records of the Western Australian Museum Supplement* **61**, 449–464.
- Christidis L, Boles WE (2008) *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing, Collingwood, Victoria.
- Dell J, Chapman A, Kitchener DJ, Muir BG (1979) Biological Survey of the Western Australian Wheatbelt. Part 9: Marchagee Nature Reserve. *Records of the Western Australian Museum Supplement* **8**, 50 pp.
- Department of Agriculture and Food Western Australia (1990). *Soil – Land Systems of the South West of Western Australia*. Department of Agriculture and Food Western Australia, Perth.
- Kitchener DJ, Chapman A, Dell J, Muir BG (1979) Biological Survey of the Western Australian Wheatbelt. Part 10: Buntine, Nugadong, and East Nugadong Nature Reserves and Nugadong Forest Reserve. *Records of the Western Australian Museum Supplement* **9**, 127 pp.
- McKenzie NL, May JE (2003) *A Biodiversity Audit of Western Australia's Biogeographical Subregions in 2002*. Department of Conservation and Land Management, Perth, Western Australia.
- Richards J, Algar D (2008) Controlling feral animals in the rangelands. *Landscape* **23**, 52–58.
- Saunders DA, Ingram JA (1995) *Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of Wheatbelt Avifauna*. Surrey Beatty and Sons, Chipping Norton, NSW.
- Saunders DA, Rowley I, Smith GT (1985) The effects of clearing for agriculture on the distribution of cockatoos in the south-west of Western Australia. In *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management* (eds A Keast, H Recher, H Ford, D Saunders), pp 309–321. Surrey Beatty and Sons, Sydney.
- Van Vreeswyk AME, Godden PT (1998) *Pastoral Resources and their Management in the Sandstone – Yalgoo – Paynes Find Area, Western Australia*. Agriculture Western Australia, Perth.

