Winter bird assemblages across an aridity gradient in south-west Western Australia

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Abstract

Avian assemblages of eight sites located along a 625km gradient across south-west Western Australia were recorded during the winters of 2004 and 2006. The total number of species observed was 92, with 10 sighted only in 2004, 14 sighted only in 2006, with the remaining 68 sighted during both survey periods. Measures of site species richness, diversity and evenness were determined for each site and for each sampling year and the turnover rates of avifauna species categorized as either sedentary or locally nomadic versus either migratory or nomadic between years were determined. The similarity between avifauna assemblages was determined by Detrended Correspondence Analysis and related to environmental data by correlation analysis and analysis of variance. Assemblage similarity between years at each site was greater than similarity between adjacent sites in the same year. However, avifauna similarity was related more to average annual precipitation than geographic proximity and was secondarily influenced by the presence of flowering trees and shrubs. There was no relationship between position on the geographic gradient and bird assemblage richness, diversity, evenness or dominance. Turnover rates between years of sampling of the regionally-nomadic and migratory species were significantly higher than sedentary and locally-nomadic species. A number of species showed discontinuous distributions in the central Wheatbelt, further documenting the impact of clearing on the avifauna of southwestern Western Australia.

Keywords: Avifauna richness, diversity, evenness and dominance, detrended correspondence analysis, inter-annual variation, species turnover rates, aridity gradient, south-west Western Australia

Introduction

The south-west corner of Western Australia has long been recognised as forming a natural floristic (Beard 1990) and faunal (Kikkawa & Pearse 1969) region. The extended geologic history and isolation from other similar climatic regions has allowed a long period for the Western Australian fauna to evolve close interactions with the vegetation and other organisms. However, Beard's (1990) South-West Botanical Province is not a strictly uniform region of vegetation and gradually changes, structurally and floristically, to the east and north. The vegetation changes have been related to the gradually declining rainfall (Beard 1990). Although Kikkawa & Pearse's (1969) South-western Faunal Sub-region overlaps this botanical province, it is not well known whether the avifauna assemblages also show such gradient changes. Eastern and northern Australian studies on bird assemblages have generally shown poor cohesion between the vegetational communities and avifaunal assemblages (Woinarski *et al.* 1988; Recher *et al.* 1991). However, Abbott (1999), using original distributions by Storr (1991), shows some evidence that the Western Australian central Wheatbelt once had higher species richness than regions of the Jarrah and Wandoo forests to the west and more arid regions to the east.

The objectives of this study were: 1) to document the winter assemblages of the avifauna in a range of sites along a gradient of increasing aridity; 2) to consider variation between two different years of sampling; 3) to relate patterns of avifauna distribution to particular environmental conditions.

Methods

Study sites

Observations were made at eight avifauna-sampling sites (Fig. 1). The end points of the sampling gradient were approximately 625km apart (825km by road) and covered an annual mean precipitation range from 1050mm at Mundaring to 230mm at Leinster (Table 1). Although the sites were on average 118 ± 64 km apart, there was a large decrease in rainfall from Mundaring to Durokoppin and then a more gradual decrease in total annual precipitation over the five remaining sampling sites. Local rainfall in the three months (April–June) preceding the 2004 sampling was significantly higher than the corresponding period preceding the 2006 sampling (paired $t = 2.80$, $p \leq 0.05$).

Although the vegetation species composition varied

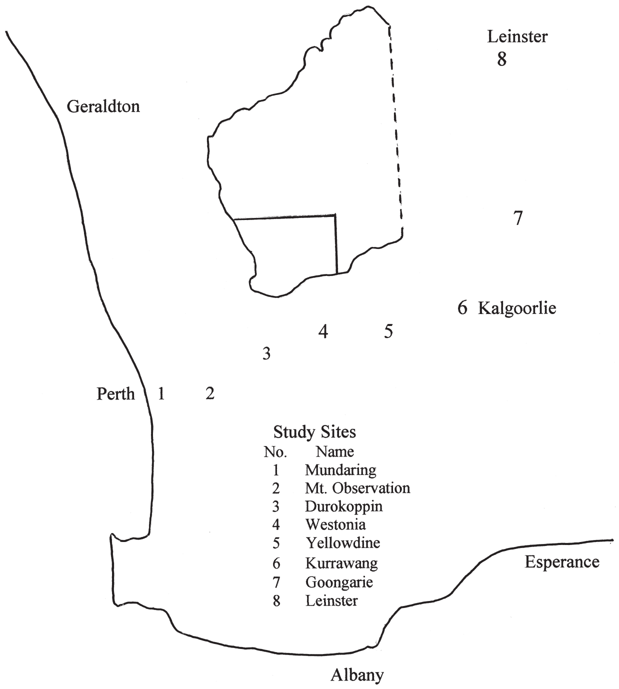

Figure 1. Approximate geographic position of the eight avian sampling sites in south-west Western Australia.

between sites, all sites chosen had a single canopy stratum dominated by eucalypt species, an understorey of shrubs and a litter layer that indicated a several-year period without fire (Table 2). Care was made to sample an area typical of the regional vegetation. A subjective assessment of the relative availability of flower resources was made during each sampling.

Sampling

At each avifauna-sampling site, bird observations were recorded over six separate time periods consisting of three early morning and three late afternoon sessions, each of two hours duration. All field observations were undertaken by the first two authors working together to share observation and recording. The area sampled was estimated using pedometer walking distances and a lateral observation region of 25 m on each side of the walking line. Census data were obtained by walking slowly forward, stopping to identify birds observed by sight and then proceeding when all birds at that location were recorded. Using this technique, area of sampling was determined to be between 15 and 21 ha for the range of sampling sites (Table 1).

Preliminary analysis of the bird richness data indicated that the total of 12 hr of observation was sufficient to maximize completeness of the sample as 90% of the final site richness value was always achieved after ≤8 hr and 95% after ≤10 hr of observation. The precautions of Watson (2003) were also followed to ensure the sampling area was representative of the regional vegetation and sampling effort was comparable between study sites. All field sampling was carried out between 14 July and 12 August 2004 and 16 July and 22 August 2006, proceeding sequentially from Mundaring to Leinster in each sampling year. Windy and rainy days were avoided, so the time required to complete the three morning and three afternoon samples took between three and five days at each site.

Site avifauna richness was the total number of bird species recorded at each site during the three-day sampling period. Three measures of site species heterogeneity were calculated. The Shannon indices of diversity ($H' = -\Sigma p_i \log_{10} p_i$) and evenness ($J' = H'/H'_{max}$) and the Simpson index of dominance ($D = \Sigma p_i^2$), where "p_i" equals the proportion for the ith species, combine information on both species richness and species evenness (Peet 1974). The Shannon indices are biased towards species richness, while the Simpson index of dominance is biased toward the abundance of the most common species (Magurran 1988). Statistical comparisons between the sample species diversity values employed the method of Hutcheson (1970). Spearman's rank correlation tests were used to compare patterns of avifauna assemblage characteristics. Site richness, evenness and dominance between-year comparisons were made by correlation analysis.

The total number of observations recorded during the 12 hr of sampling was determined and the percentage recorded for each species provided the matrix of data for comparisons of avifauna assemblage structure between sites and years by Detrended Correspondence Analysis (DCA) using CANOCO version 3.11.5 (Jongman *et al.* 1995). Paired t-tests were used to determine differences

Table 1

Study site locations for avian observations. Mean annual rainfall (mm) and the rainfall of the three months preceding the sampling period approximated from data from nearest weather station (Australian Bureau of Meteorology – www.bom.gov.au/climate). Estimated area sampled (ha) determined from mean pedometer readings and 50m sampling width. Distance by road from Mundaring is also provided.

Site No.	Site Name	Longitude-Latitude	Annual Rainfall	Seasonal Rainfall 2004	Seasonal Rainfall 2006	Area (ha)	Distance (km)
1)	Mundaring	116° 11'E 31° 55'S	1050	330	108	15.0	0
2)	Mt. Observation	116° 31'E 31° 53'S	460	174	64	15.8	45
3)	Durokoppin	117° 31'E 31° 25'S	330	123	45	16.4	180
4)	Westonia	118° 41'E 31° 15'S	310	127	83	21.0	270
5)	Yellowdine	119° 39'E 31° 17'S	290	82	49	21.0	320
6)	Kurrawang	120° 25'E 30° 45'S	260	33	26	21.6	495
7)	Goongarrie	121° 10'E 29° 55'S	250	62	16	20.0	605
8)	Leinster	121° 45'E 27° 45'S	230	56	4	21.7	825

Table 2

Characteristics of bird observation sites including dominant tree species, common genera of the shrub layer, important features of the ground layer, and subjective assessment of relative amounts of flowering.

Site No.	Name	Tree Layer ≥3m	Shrub Layer >10cm<3m	Litter/Ground ≤10cm	Flowering 2004	2006
1)	Mundaring	*Eucalyptus marginata* *Corymbia calophylla*	*Dryandra sessilis* + many other spp.	Mostly covered by leaves, twigs	++++	+++
2)	Mt. Observation	*E. wandoo* *E. accedens*	*D. sessilis* + many other spp.	Occasional litter, mostly exposed gravel	+++	++
3)	Durokoppin	*E. salmonopholia* *E. loxophleba*	*Dryandra, Hakea* *Melaleuca,* *Allocasuarina*	Scattered litter in woodlands, sparse in shrubs	+	–
4)	Westonia	*E. transcontinentalis* *E. longicornis* *E. salubris*	*Melaleuca, Santalum* *Hakea,* *Allocasuarina*	Some dense areas of leaves, twig, others sparse	++	–
5)	Yellowdine	*E. salubris* *E. transcontinentalis*	Scattered *Melaleuca* *Hakea, Acacia*	Sparse litter layer	+	++
6)	Kurrawang	*E. lesouefii* *E. clelandii* *E. transcontinentalis*	*Acacia, Maireana* *Atriplex* *Melaleuca*	Litter under trees, very sparse elsewhere	+++	+
7)	Goongarie	*E. oleosa*	*Acacia, Allocasuarina* *Triodia*	Litter with mallees sparse elsewhere	+	–
8)	Leinster	*E. gongylocarpa* *E. kingsmillii* *E. oldfieldii*	*Dodonea, Cassia* *Grevillea* *Triodia*	Sparse litter, mostly under mallees	–	++

in axis position for sites between years. Correlation analysis was used to compare the DCA site axis scores with a range of the geographic, environmental and avifauna data.

For each site, avifauna species turnover rate was determined between sampling years as T = 100[(d+a)/s], where "d" is the number of local departures (number of species not recorded at the site during the 2006 survey, but had been recorded during the initial 2004 survey), "a" is the number of local arrivals (number of species recorded at the site during 2006, but not recorded during the 2004 survey), and "s" is the total number of species observed at the site during both survey periods (Maron *et al.* 2005). Turnover rates between 1) the total, 2) sedentary and locally nomadic, and 3) migratory and nomadic species classes were compared by analysis of variance.

Results

Patterns of avian observations

A total of 92 species were recorded in the two surveys of the eight sites along the 625 km aridity gradient across south-west Western Australia (Appendix 1). Ten species were sighted only in 2004 and 14 species sighted only in 2006, with the remaining 68 species sighted during both survey periods. No species was recorded during both sampling years in all eight sites, however, the Weebill was sighted in 15 of the 16 samples and the Australian Ringneck and the Australian Raven were recorded in 14 of the 16 samples. Other widely occurring species recorded in at least 12 of the 16 samples were the Brown Honeyeater, Grey Shrike-thrush, Red Wattlebird, Striated Pardalote, Pied Butcherbird and the Yellow-throated Miner.

Although many were widespread, some species with low or high species DCA scores favoured the moister or drier ends of the aridity gradient. For example, the New Holland Honeyeater was the most commonly observed bird in the Jarrah forest study site at Mundaring, accounting for more than a quarter of the observations in both sampling years. Other species with predominant observation percentages in the Mundaring and Mt. Observation samples were the Red-capped Parrot, Western Spinebill, Scarlet Robin and Western Thornbill.

The most commonly observed birds of the central Wheatbelt and Goldfield woodlands sites were the widespread Red Wattlebird, Weebill, Australian Ringneck, Yellow-throated Miner and the Striated Pardalote, along with the more restricted regional species, the Chestnut-rumped Thornbill, White-eared Honeyeater and Yellow-rumped Thornbill. Species with high species DCA axis 1 scores were the commonly observed species recorded at the most arid end of the gradient. These included the Yellow-throated Miner, Crested Pigeon and Little Crow.

The first axis of the DCA site ordination, which explained 26% of the avifauna assemblage variation, separated the southwestern sites on the low score end of the axis and the northeastern sites on the high score end of the axis (Fig. 2). Sites of the central Wheatbelt tended

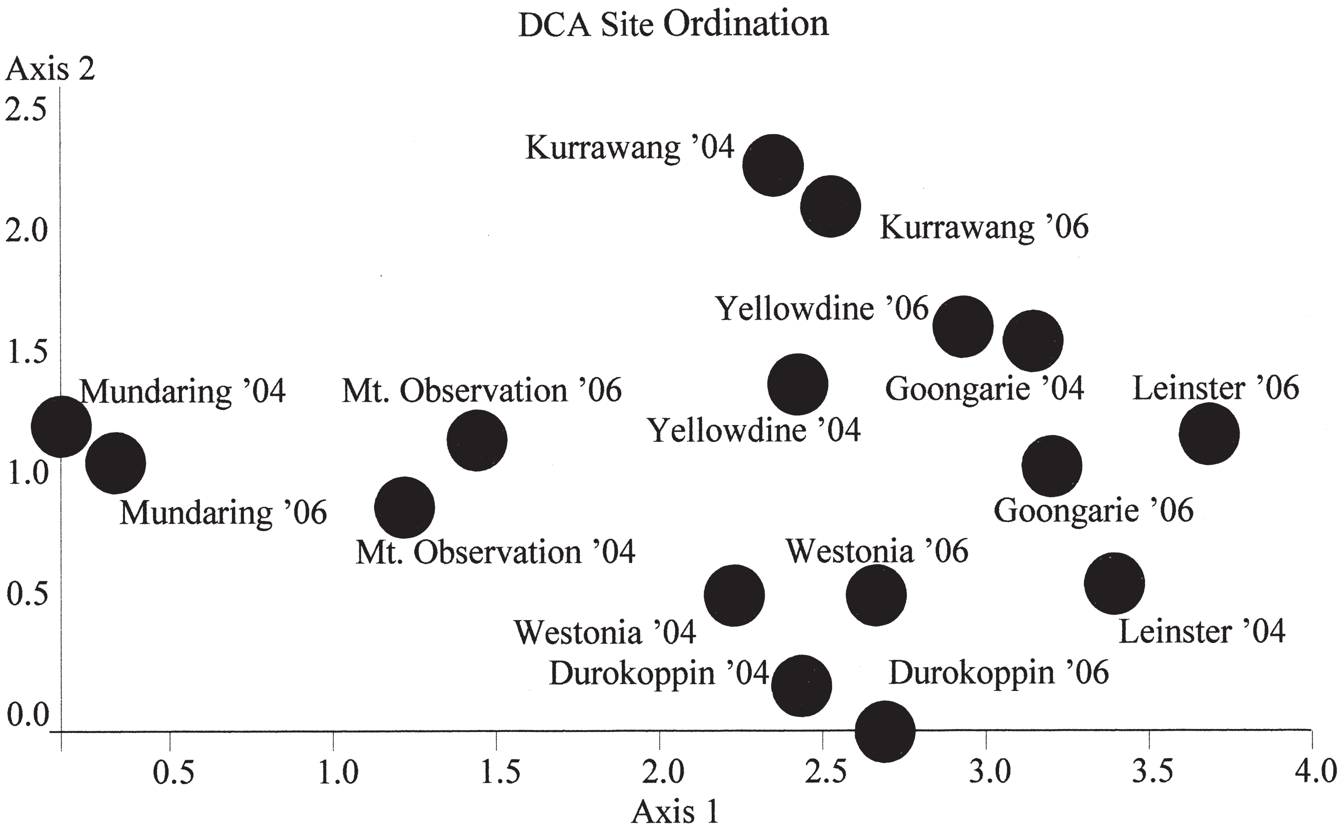

Figure 2. Sample positions on first and second Detrended Correspondence Analysis ordination axes.

to be in the central region of axis 1, but were separated with the Durokoppin samples at the lower score end of axis 2 and the remaining samples appeared sequentially as in their geographic position with increasing axis 2 scores. The second DCA axis explained a further 12% of the avifauna assemblage variation. The two DCA ordination axes also revealed that for each site the assemblage similarity between years was greater than between geographically adjacent sites. The difference between axis 1 scores for the same site between years was significantly less than the mean axis 1 scores between adjacent sites (paired t = 2.28, p ≤ 0.05). This was also true for DCA axis 2 values (paired t = 3.57, p ≤ 0.01).

Bird assemblage characteristics

Bird assemblage characteristics varied between years and sites (Table 3). Richness of the samples ranged from low values of 15 at the Leinster site in 2004 and 20 species at the Goongarie site in 2006 to highs of 31 species recorded at Durokoppin in 2004 and 35 species recorded in Mt. Observation in 2006. However, there was no relationship between site richness in 2004 and site richness in 2006 (correlation analysis r = 0.35, p > 0.05). The Shannon species diversity of avifauna samples ranged between 0.87 for the 2006 Goongarie sample and 1.30 for the 2006 Mt. Observation sample, but the diversities at each site in 2004 were not significantly correlated with those measured in 2006 at the same site (r

Table 3

Avian site richness, Shannon indices of diversity and evenness, and Simpson index of dominance values. Shannon diversity values with different superscript letters are statistically different at p≤0.05 by the method of Hutcheson (1970).

	Location Name	Species Richness		Shannon Indices Diversity		Shannon Indices Evenness		Simpson Index Dominance	
		2004	2006	2004	2006	2004	2006	2004	2006
1)	Mundaring	23	32	1.11^{cd}	1.19^{ef}	0.83	0.79	0.12	0.11
2)	Mt. Observation	26	35	1.09^{cd}	1.30^{g}	0.77	0.84	0.12	0.07
3)	Durokoppin	31	32	1.24^{fg}	1.13^{de}	0.81	0.76	0.09	0.12
4)	Westonia	24	31	1.05^{c}	1.25^{fg}	0.76	0.84	0.13	0.08
5)	Yellowdine	29	34	1.19^{ef}	1.28^{g}	0.82	0.83	0.09	0.07
6)	Kurrawang	24	28	0.96^{b}	1.12^{d}	0.69	0.77	0.16	0.16
7)	Goongarie	27	20	1.10^{cd}	0.87^{a}	0.77	0.66	0.12	0.27
8)	Leinster	15	25	0.96^{b}	1.09^{cd}	0.82	0.78	0.14	0.11

= 0.16, $p > 0.05$). Species diversities between years for individual sites showed statistically differences, however, overall diversity for 2004 was not different compared to 2006, as diversity increased at six sites in 2006, but decreased at two sites. As with the richness and diversity values, there were no overall differences between sampling years for evenness ($r = 0.11$, $p > 0.05$) and dominance ($r = 0.22$, $p > 0.05$). Also, sites, which ranked high in 2004, did not necessarily rank high in 2006 for richness (Spearman rank correlation $r = 0.21$, $p > 0.05$), diversity ($r = 0.28$, $p > 0.05$), evenness ($r = 0.04$, $p > 0.05$) or dominance ($r = 0.30$, $p > 0.05$). Although the DCA ordination indicated that the bird species composition changed between Mundaring and Leinster, the characteristics of richness, diversity, evenness and dominance between sites showed no gradient trends.

Species turnover between years averaged 45% for all birds, 40% for birds categorized as sedentary or locally nomadic and 60% for birds categorized as migratory or nomadic (Table 4). The degree of bird assemblage turnover of migratory and nomadic species was statistically greater than the turnover of sedentary and locally nomadic species (ANOVA $F_{d.f=21,2} = 3.65$, $p \leq 0.05$).

Table 4

Bird assemblage species turnover between years at the eight sampling sites. Percentage turnover values for 1) all birds (All), 2) birds categorized as sedentary or locally nomadic (Sed/LocNom) or 3) migratory or nomadic (Mig/Nom) are presented for the mean±se of all sites and for each site individually.

Site	Species Turnover Percentage All	Sed/LocNom	Mig/Nom
All Sites – mean±se	44.9±3.4	40.0±4.3	59.1±7.3
1) Mundaring	42.9	26.1	75.0
2) Mt. Observation	50.0	51.9	46.2
3) Durokoppin	29.7	22.2	50.0
4) Westonia	42.9	33.3	63.6
5) Yellodine	34.2	37.0	33.3
6) Kurrawang	54.3	54.2	54.5
7) Goongarie	48.4	47.8	50.0
8) Leinster	57.1	47.8	59.1

Gradient relationships

Variation in avifauna assemblage structure was most strongly related to annual rainfall (Table 5). Annual rainfall had a slightly higher correlation with the first DCA axis site scores than did the geographic separation from the western-most site to the other sites, measured as difference in the degrees of latitude and longitude. The correlation analyses also confirmed that there was no relationship between bird assemblage structure as defined by the DCA analysis with species richness, species diversity, evenness and dominance.

Avifauna assemblage structure was secondarily influenced by the presence of flowers as a food resource (Table 5). The second DCA axis of community variation showed this pattern with significant relationships with the percentage of observations of all the 14 honeyeater species to the total number of observation of all species and the number of members of the Meliphagidae observed in the site. The increase of locally nomadic honeyeater species into sites with high axis 2 scores led to a significant correlation between the number of honeyeaters and DCA axis 2 scores.

The generally drier conditions of 2006 compared to 2004 did not seem to influence bird assemblage variation, as there was no major division between sampling years on either of the two primary DCA axes. Rainfall in the three-month period just prior to sampling showed the same general pattern as the long-term annual rainfall totals for the sampling sites, although the correlation coefficient was less with the former variable.

Discussion

Gradient patterns

At continental scales, animal assemblages are generally more diverse in habitats that are more productive (Ricklets 1980). Tropical areas have more bird species than temperate areas and forests have more bird

Table 5

Correlations and level of probability with site DCA axis scores for selected geographic and environmental characteristics.

Characteristic	Axis 1	Prob.	Axis 2	Prob.
Annual rainfall (mm)	-.927	0.01	.001	n.s.
Site separation (degrees from Mundaring)	.833	0.01	.189	n.s.
3-month prior rainfall	-.745	0.01	-.185	n.s.
% Observations by spp. of the Honeyeaters	-.379	n.s.	.829	0.01
Turnover % of sedentary & loc. nomadic spp.	.299	n.s.	.582	0.05
Species diversity	-.287	n.s.	-.252	n.s.
Number of honeyeater species at site	-.283	n.s.	.742	0.01
Evenness	-.254	n.s.	-.230	n.s.
Species richness	.232	n.s.	.009	n.s.
Dominance	.209	n.s.	.157	n.s.
Turnover % of all species	.123	n.s.	.489	n.s.
Turnover % of nomadic and migratory spp.	.049	n.s.	-.181	n.s.
Total number of observations at site	.039	n.s	.114	n.s.

species than deserts. In the Northern Hemisphere, bird species diversity within more limited geographic areas is strongly related to the structural diversity (primarily the number of vegetation layers) of the habitat (MacArthur & MacArthur 1961; Moss 1978; James & Wamer 1982). In Australia, there is less agreement regarding habitat factors affecting avian species composition, richness and diversity (Ford 1989; Woinarski *et al.* 1997). In a limited study from eastern Australia, Recher (1969) found that foliage height diversity was an important determinant of bird species richness. However, in a study of several Western Australian wandoo woodland habitats, Arnold (1988) found that vegetation structural diversity was not such a strong determinant of avian diversity and suggested that floristic diversity was a more important factor affecting avian diversity at the regional scale. In the present survey, even though there was a gradual change in species composition from Mundaring to Leinster, there was no general trend in site richness and diversity characteristics despite the survey extending more than 625 km in length. Although there was a general decrease in canopy tree height and density over the aridity gradient, our findings support the broad conclusions of Keast (1985) that eucalypt communities throughout Australia vary little in total avian species diversity.

Inter-annual variation

Although the species composition of sites was more similar between years than between that of adjacent sites, the general lack of correspondence in site richness between years found in this study has been recorded previously. Species richness of Victorian woodland sites measured in 1994–95 and again in 2001–02 was unrelated, although bird densities were almost three times higher in the second sampling (Maron *et al.* 2005). Large annual population fluctuations, local absences and local influxes may be common events, especially in arid Australian habitats (James *et al.* 1995). Maron *et al.* (2005) reported a higher turnover of migratory and nomadic species than more sedentary species. There was a similar statistical difference in bird assemblage turnover values between these two categories in our study. Honeyeaters appear to be particularly erratic and habitats with flowers have generally been associated with large increases in honeyeaters (Ford & Paton 1985; Brown & Hopkins 1996; Franklin & Noske 1999), but not always (French *et al.* 2003). The number of honeyeater species at a site and the proportion of observations of honeyeaters to all bird species at the site were major determinants in the species assemblage variation along the second DCA site ordination axis in our study.

Conservation of avifauna in the central Wheatbelt

As a consequence of the destruction of significant areas of central Wheatbelt vegetation, the avifauna of this region has also lost significant components (Kitchener *et al.* 1982; Saunders 1989; Lynch & Saunders 1991) with vegetation remnants now dominated by a core of widely distributed, abundant and often highly competitive bird species. The records of a number of bird species of this study also showed distributions that were discontinuous in the central Wheatbelt region. These included the Yellow-plumed Honeyeater, Black-faced Cuckoo-shrike, Rufous Treecreeper, Golden Whistler and Grey Currawong. These species have been previously listed amongst other species that are now rare or extinct in the central Wheatbelt (Saunders & de Rebeira 1991; Birds Australia Western Australia n.d.). Long-term, detailed work at Durokoppin Reserve and other Wheatbelt remnants attribute the loss of these species and a number of others to the loss of native vegetation to agriculture (Saunders 1989; Saunders & Curry 1990). Durokoppin Reserve, however, was a survey site with relatively high richness and species diversity in our study. Saunders & de Rebeira (1991) suggest that remnant native vegetation blocks within mostly cleared agricultural land are actually carrying more species than they are capable of supporting over the long term and further species extinctions will inevitably occur from this region.

Our study indicates that the central Wheatbelt study sites are not currently richer in bird species compared to the more completely vegetated areas to the southwest and northeast, but our records do highlight gaps in the continuous distribution of a number of species. Protection of the present woodland remnants is essential to maintain the current level of bird species diversity in this region of south-west Western Australia.

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Appendix 1

Species composition, total number of observation and percentage of observations for each site for each year sorted by DCA species axis 1 scores. Common names and scientific nomenclature from Johnstone (2001), Johnstone & Storr (1998), (2004), Morcombe (2000) or Simpson & Day (2004). Status from Saunders & Ingham (1995), Morcombe (2000) and/or Simpson & Day (2004): S=Sedentary, L=Locally nomadic or migratory, N=Nomadic, M=Migratory. Detrended Correspondence Analysis Species Ordination axis 1 and 2 scores. Species with no scores were not included in the analysis (see text).

			Mundaring		Mt. Observation		Durokoppin		Westonia		Yellowdine		Kurrawang		Goongarrie		Leinster			
	Year of Observations	**=**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**2004**	**2006**	**DCA**	**DCA**
	Total Number of Observations	**=**	**270**	**398**	**199**	**476**	**442**	**519**	**403**	**333**	**336**	**516**	**494**	**341**	**364**	**244**	**164**	**313**	**Axis 1**	**Axis 2**
Common Name	**Scientific Name**	**Status**																		
New Holland Honeyeater	*Phylidonyris novaehollandiae*	L	28.3%	25.6%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-56	112
Red-capped Parrot	*Platycerus spurius*	S	6.3%	10.3%	-.-	0.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-51	105
Western Spinebill	*Acanthorhynchus superciliosus*	L	7.8%	10.6%	-.-	0.8%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-49	107
Scarlet Robin	*Petroica multicolor*	L	7.4%	3.5%	1.0%	0.8%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-44	118
Western White-naped Honeyeater	*Melithreptus chloropsis*	S	4.5%	2.3%	-.-	2.1%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-29	116
Spotted Pardalote	*Pardalotus punctatus*	N	3.3%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
White-browed Scrub Wren	*Sericornis frontalis*	S	-.-	1.0%	0.5%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-19	94
Golden Whistler	*Pachycephala pectoralis*	L	1.1%	0.2%	0.5%	-.-	-.-	-.-	-.-	0.3%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-14	76
Short-billed Black Cockatoo	*Calyptorhynchus latirostris*	N	3.7%	-.-	4.0%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-14	122
Western Wattlebird	*Anthochaera lunulata*	N	1.5%	3.0%	2.0%	1.3%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-10	105
Western Thornbill	*Acanthiza inornata*	S	8.9%	3.5%	18.1%	5.7%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	6	114
Silvereye	*Zosterops lateralis*	M/N	0.7%	0.8%	1.5%	1.1%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	9	110
Laughing Kookaburra	*Dacelo novaeguineae*	S	0.4%	0.8%	0.5%	0.8%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.3%	-.-	-.-	-.-	16	114
Splendid Fairy Wren	*Malurus splendens*	S	2.2%	0.5%	6.5%	0.8%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.8%	1.3%	-.-	-.-	31	117
Wedge-tailed Eagle	*Aquila audax*	S	-.-	0.8%	-.-	0.2%	0.2%	-.-	-.-	-.-	-.-	-.-	0.2%	-.-	-.-	-.-	-.-	0.3%	42	124
Common Bronzewing	*Phaps chalcoptera*	L	0.4%	3.5%	-.-	2.3%	-.-	0.2%	0.2%	0.9%	1.8%	0.4%	0.2%	0.3%	-.-	-.-	-.-	-.-	46	133
Brown Honeyeater	*Lichmera indistincta*	L	7.8%	8.0%	12.1%	11.1%	3.6%	0.6%	-.-	-.-	4.4%	3.9%	4.3%	2.1%	-.-	-.-	1.2%	1.3%	50	170
Rainbow Lorikeet	*Trichoglossus haematodus*	N	1.5%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	M/N	-.-	0.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Tawny-crowned Honeyeater	*Phylidonyris melanops*	N	-.-	-.-	1.0%	1.3%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	56	110
Mistletoe Bird	*Dicaeum hirundinaceum*	N	-.-	0.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.3%	-.-	-.-	-.-	63	139
Western Corella	*Cacatua pastinator*	N	-.-	-.-	-.-	-.-	0.5%	-.-	1.7%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	67	180
White-cheeked Honeyeater	*Phylidonyris nigra*	L	-.-	-.-	0.5%	10.3%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	73	110
Grey Fantail	*Rhipidura fuliginosa*	M	-.-	0.8%	20.1%	4.0%	6.3%	4.2%	0.2%	0.3%	1.5%	0.2%	-.-	-.-	0.8%	-.-	-.-	-.-	74	0
Rufous Whistler	*Pachycephala rufiventris*	M	-.-	1.0%	1.5%	0.2%	-.-	0.4%	-.-	-.-	-.-	-.-	-.-	-.-	0.8%	1.3%	-.-	-.-	76	70
Painted Button-quail	*Turnix varia*	S	-.-	-.-	1.0%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Rufous Tree-creeper	*Climacteris rufa*	S	-.-	-.-	1.0%	2.7%	-.-	-.-	-.-	-.-	0.9%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	79	144
Australian Magpie	*Gymnorhina tibicen*	L	-.-	3.3%	1.5%	1.1%	0.7%	0.8%	-.-	0.6%	0.9%	-.-	0.4%	-.-	-.-	-.-	2.4%	1.6%	81	42
Grey Shrike-thrush	*Colluricincla harmonica*	S	2.2%	0.5%	0.5%	0.2%	0.9%	1.4%	2.7%	0.6%	-.-	1.0%	0.2%	1.2%	1.1%	-.-	-.-	-.-	94	22
Varied Sittella	*Daphoenositta chrysoptera*	S	1.5%	0.8%	2.0%	-.-	1.1%	1.2%	1.2%	1.8%	1.8%	0.8%	-.-	-.-	-.-	3.1%	-.-	-.-	107	10
Tree Martin	*Petrochelidon nigricans*	M	-.-	-.-	2.5%	8.2%	5.7%	4.0%	2.0%	3.9%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	132	-63
Western Gerygone	*Gerygone fusca*	S	-.-	-.-	-.-	1.7%	-.-	1.2%	-.-	-.-	0.3%	0.6%	-.-	-.-	-.-	-.-	-.-	-.-	139	14
Red Wattlebird	*Anthochaera carunculata*	N	6.3%	4.5%	-.-	4.6%	1.1%	0.4%	9.9%	4.5%	12.0%	8.1%	28.1%	13.8%	5.4%	0.4%	-.-	-.-	150	262
Dusky Woodswallow	*Artamus cyanopterus*	M	-.-	-.-	-.-	3.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	8.5%	-.-	-.-	-.-	-.-	195	333
Australian Ringneck	*Platycercus zonarius*	S	1.5%	4.0%	2.0%	4.2%	18.1%	16.4%	17.2%	15.6%	3.8%	3.3%	-.-	0.6%	0.8%	-.-	7.9%	1.3%	212	-80
Australian Raven	*Corvus coronoides*	S	0.7%	1.0%	1.5%	1.7%	0.9%	0.8%	4.7%	9.0%	8.5%	1.7%	1.6%	3.5%	-.-	-.-	1.2%	2.2%	220	108
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	L	-.-	0.8%	-.-	-.-	0.7%	0.4%	-.-	-.-	-.-	-.-	0.2%	1.8%	1.4%	-.-	0.6%	1.3%	220	205
Singing Honeyeater	*Lichenostomus virescens*	N	-.-	1.0%	0.5%	1.1%	0.2%	-.-	0.5%	-.-	-.-	-.-	3.8%	0.9%	4.8%	-.-	-.-	2.9%	229	243
Yellow-plumed Honeyeater	*Lichenostomus ornatus*	L	-.-	-.-	2.5%	8.0%	-.-	-.-	-.-	-.-	3.8%	11.1%	19.0%	26.4%	-.-	-.-	-.-	1.6%	250	329
Galah	*Cacatua roseicapilla*	S	1.5%	4.0%	-.-	0.2%	16.1%	19.1%	19.0%	10.2%	-.-	2.1%	-.-	-.-	-.-	-.-	14.6%	4.2%	257	-100
Willie Wagtail	*Rhipidura leucophrys*	L	-.-	-.-	-.-	0.4%	-.-	-.-	-.-	-.-	0.6%	0.2%	-.-	-.-	-.-	0.4%	-.-	0.3%	269	183
Grey Currawong	*Strepera versicolor*	S	0.4%	0.5%	-.-	-.-	-.-	-.-	2.7%	4.8%	1.2%	1.4%	-.-	-.-	1.4%	3.1%	-.-	-.-	272	5
Red-capped Robin	*Petroica goodenovii*	N	-.-	-.-	-.-	1.5%	0.2%	3.3%	0.5%	-.-	-.-	-.-	-.-	0.3%	-.-	2.2%	-.-	0.6%	276	-32

Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	S	-.-	-.-	-.-	1.9%	2.3%	3.7%	0.2%	0.6%	2.3%	2.3%	-.-	2.9%	-.-	-.-	-.-	1.6%	288	88
Weebill	*Smicrornis brevirostris*	S	-.-	1.3%	14.6%	13.0%	10.0%	19.6%	20.4%	14.1%	20.2%	10.3%	11.3%	11.4%	24.2%	48.7%	23.2%	11.8%	293	73
White-fronted Chat	*Epthianura albifrons*	N	-.-	-.-	-.-	0.8%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Chimming Wedgebill	*Psophodes occidentalis*	S	-.-	-.-	-.-	-.-	0.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Black-faced Woodswallow	*Artamus cinereus*	N	-.-	-.-	-.-	-.-	1.4%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
Western Yellow Robin	*Eopsaltria griseogularis*	L	-.-	-.-	-.-	-.-	0.5%	0.2%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	296	-192
Jacky Winter	*Microeca fascinans*	L	-.-	-.-	-.-	-.-	0.9%	0.6%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	300	-190
White-fronted Honeyeater	*Phylidonyris albifrons*	N	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	6.9%	-.-	-.-	-.-	-.-	0.3%	316	401
Elegant Parrot	*Neophema elegans*	L	-.-	-.-	-.-	-.-	2.0%	2.7%	-.-	2.4%	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	317	-147
Striated Pardalote	*Pardalotus striatus*	M	-.-	0.8%	-.-	1.9%	3.6%	1.5%	3.7%	2.7%	6.7%	5.2%	0.2%	3.2%	20.3%	1.3%	-.-	-.-	318	127
Purple-gaped Honeyeater	*Lichenostomus cratitius*	N	-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.6%	-.-	0.2%	1.0%	-.-	-.-	-.-	-.-	-.-	325	281
Inland Thornbill	*Acanthiza apicalis*	L	-.-	0.8%	-.-	-.-	2.0%	0.4%	-.-	0.9%	0.9%	3.1%	-.-	2.6%	1.7%	6.6%	1.8%	1.6%	332	147
White-eared Honeyeater	*Lichenostomus leucotis*	L	-.—	-.—	-.—	-.—	6.3%	1.9%	5.4%	5.7%	2.6%	5.8%	4.0%	6.7%	4.8%	0.4%	-.—	-.—	333	142
Brown Falcon	*Falco berigora*	S	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Horsfield's Bronze Cuckoo	*Chrysococcyx basalis*	M	-.—	-.—	-.—	-.—	-.—	0.4%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	1.8%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Peregrine Falcon	*Falco peregrinus*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Australian Owlet-nightjar	*Aegotheles cristatus*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.3%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Welcome Swallow	*Hirundo neoxena*	N/M	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.9%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Major Mitchell's Cockatoo	*Cacatua leadbeateri*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	4.7%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Australian Pipit	*Anthus australis*	L	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.4%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Black-shouldered Kite	*Elanus axillaris*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Square-tailed Kite	*Lophoictinia isura*	L	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—
Pallid Cuckoo	*Cuculus pallidus*	M	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	0.2%	-.—	-.—	-.—	-.—	-.—	337	326
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	3.5%	4.8%	-.—	1.8%	-.—	-.—	-.—	-.—	337	261
Red Throat	*Pyrrholaemus brunneus*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.9%	0.9%	-.—	-.—	-.—	-.—	0.4%	-.—	-.—	338	55
Blue-breasted Fairy Wren	*Malurus pulcherrimus*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	2.4%	-.—	0.4%	-.—	0.6%	-.—	-.—	-.—	-.—	340	52
Regent Parrot	*Polytelis anthopeplus*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	1.8%	0.6%	1.0%	-.—	-.—	-.—	-.—	-.—	-.—	341	45
Grey Butcherbird	*Cracticus torquatus*	L	-.—	-.—	0.5%	-.—	-.—	1.7%	0.5%	0.3%	1.5%	0.2%	-.—	0.3%	2.3%	1.8%	2.4%	-.—	345	31
Brown-headed Honeyeater	*Melithreptus brevirostris*	L	-.—	-.—	-.—	-.—	1.4%	0.8%	1.7%	3.6%	3.8%	4.5%	1.0%	2.3%	1.7%	4.0%	-.—	-.—	348	154
White-browed Babbler	*Pomatostomus superciliosus*	S	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	1.8%	-.—	-.—	-.—	3.5%	5.4%	-.—	-.—	-.—	366	234
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	L	-.—	-.—	-.—	-.—	4.8%	6.2%	2.7%	0.9%	12.9%	10.5%	0.2%	-.—	2.8%	5.3%	5.5%	7.3%	369	55
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	1.9%	1.4%	1.5%	7.6%	2.7%	-.—	0.3%	383	231
Hooded Robin	*Petroica cucullata*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.2%	-.—	0.8%	-.—	-.—	-.—	385	232
Pied Butcherbird	*Cracticus nigrogularis*	S	-.—	-.—	-.—	-.—	2.0%	0.6%	1.2%	1.8%	0.3%	0.2%	0.6%	1.8%	0.3%	0.9%	9.1%	3.2%	401	25
Yellow-throated Miner	*Manorina flavigula*	L	-.—	-.—	-.—	-.—	5.2%	3.1%	1.0%	4.2%	-.—	-.—	13.6%	0.6%	8.2%	11.9%	18.3%	20.1%	407	144
Mulga Parrot	*Platycercus varius*	S	-.—	-.—	-.—	-.—	-.—	0.4%	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	1.2%	-.—	413	-55
Magpie Lark	*Grallina cyanoleuca*	S	-.—	-.—	-.—	-.—	0.2%	0.4%	-.—	-.—	0.6%	0.4%	0.4%	-.—	-.—	-.—	-.—	2.6%	421	172
Crested Pigeon	*Ocyphaps lophotes*	S	-.—	-.—	-.—	-.—	0.9%	1.7%	-.—	-.—	0.3%	8.9%	0.8%	0.3%	-.—	-.—	-.—	14.4%	429	182
White-winged Triller	*Lalage tricolor*	M	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.3%	-.—	-.—	-.—	-.—	-.—	-.—
Little Eagle	*Hieraaetus morphnoides*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.3%	-.—	-.—	-.—	-.—	-.—	-.—
Brown Goshawk	*Accipiter fasciatus*	L	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	-.—	-.—	-.—	-.—	-.—	-.—
Slender-billed Thornbill	*Acanthiza iredalei*	L	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	-.—	-.—	-.—	-.—	-.—
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*	L	-.—	-.—	-.—	-.—	-.--	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.3%	-.—	-.—	-.—	-.—	-.—
Nankeen Kestrel	*Falco cenchroides*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	-.—	-.—	-.—
Crested Bellbird	*Oreoica gutturalis*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	1.3%	-.—	1.6%	453	141
Little Crow	*Corvus bennetti*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	2.7%	9.8%	16.6%	472	80
Western Bowerbird	*Chlamydera guttata*	S	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.3%	-.—	-.—
Red-backed Kingfisher	*Todiramphus pyrrhopygia*	N	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	-.—	0.6%	-.—	-.—