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BIRDS OF THE ROYAL BOTANIC GARDENS, CRANBOURNE

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A survey of diurnal birds of the Royal Botanic Gardens Cranbourne (RBGC), Victoria was undertaken during most months between January 1999 and December 2004. Bird species were recorded at ten, two-hectare areas representing the major habitat types available. Incidental observations of other species were also recorded generally throughout the site. The results of the study suggest that the majority of species known from the extensive Gippsland Plains Bioregion still occur at the RBGC. A rich avifauna comprising 160 species was recorded during the study and it included a range of taxa now rare or threatened elsewhere in the region. Temporal and spatial patterns in the reporting rates of species are examined, including a comparison with a similar survey conducted at the site between 1989 and 1992. While many birds were widespread across the RBGC and present throughout the year, there were clear differences in the avifauna recorded at different sites and seasons and there was evidence of significant long-term trends in some species. The RBGC is one of the few remaining moderately sized patches of lowland vegetation in the Port Phillip-Westernport Region and is identified as an important site for the conservation of biodiversity. The performance of this and other similar sized patches of remnant vegetation in providing habitat for native birds may be crucial to the conservation of bird diversity in the region.

INTRODUCTION

There is little doubt that many birds native to southern Australia depend on remnant indigenous vegetation for habitat. However, bird communities appear to also be sensitive to the spatial configuration of the remaining vegetation (Radford *et al*. 2005; Radford and Bennett 2005). For example, bird species richness typically decreases with patch size as species that may be common in large areas of continuous forest can become rare in small patches (Saunders *et al*. 1991; Villard 1998; Seddon *et al*. 2003; Radford *et al*. 2005). Indeed some native birds may only remain in an area when very large patches of indigenous vegetation are present. As a consequence of this area-effect, the largest remaining patches of indigenous vegetation commonly support the richest bird communities (Blake 1991; Martin and Catterall 2001; Watson *et al*. 2005; Antos *et al*. 2006). The effect may be most pronounced when the total amount of habitat remaining in the landscape is small (Olsen *et al*. 2003; Radford *et al*. 2005) and may also be particularly strong in urban and peri-urban landscapes where conditions outside patches are dramatically different from those inside (Watson *et al*. 2005; Ewers and Didham 2006). As a result, relatively large patches of vegetation may be crucial for the conservation of bird communities in the extensively modified landscapes that now typify urbanised regions of Australia.

The factors potentially responsible for reduced species richness in small vegetation remnants have been canvassed extensively and are the subject of ongoing research (Villard 1998; Berry 2002; Fischer and Lindenmayer 2002; Seddon *et al*. 2003; Ewers and Didham 2006). The effect has been linked to a range of factors such as change in environmental conditions at patch edges (Saunders *et al*. 1991; Major *et al*. 2001; Antos and White 2004; Ewers and Didham 2006), altered demographic processes (MacArthur and Wilson 1967; Connor and McCoy 1979; Loyn 1987; Reed 2004; Ewers and Didham 2006) and altered ecological regimes (Loyn 1987; Martin and Catterall 2001). Many of these effects also have a strong temporal component (Loyn 1987; Tilman *et al*. 1994) and are likely to be influenced by the degree of difference between the patch and the surrounding land, suggesting a potential for dramatic reduction in species richness in older urban vegetation remnants.

In the greater Melbourne area most of the original indigenous woodland and heathland has been replaced by a structurally simple, exotic matrix of residential, industrial and agricultural land. Indigenous vegetation in the region is now largely confined to small, widely dispersed and often highly degraded remnants. Structurally complex vegetation like that found in the interiors of large forest remnants elsewhere has become uncommon (Calder 1986; Oates and Taranto 2001). The transformation of the landscape was largely complete by the end of the 19th century but ongoing vegetation removal and modification has continued to contract the remaining fragments of indigenous vegetation during the 20th century (e.g. Calder 1986). Recent evidence from elsewhere in the Gippsland Plains Bioregion suggests that these small patches of vegetation may be inadequate to effectively

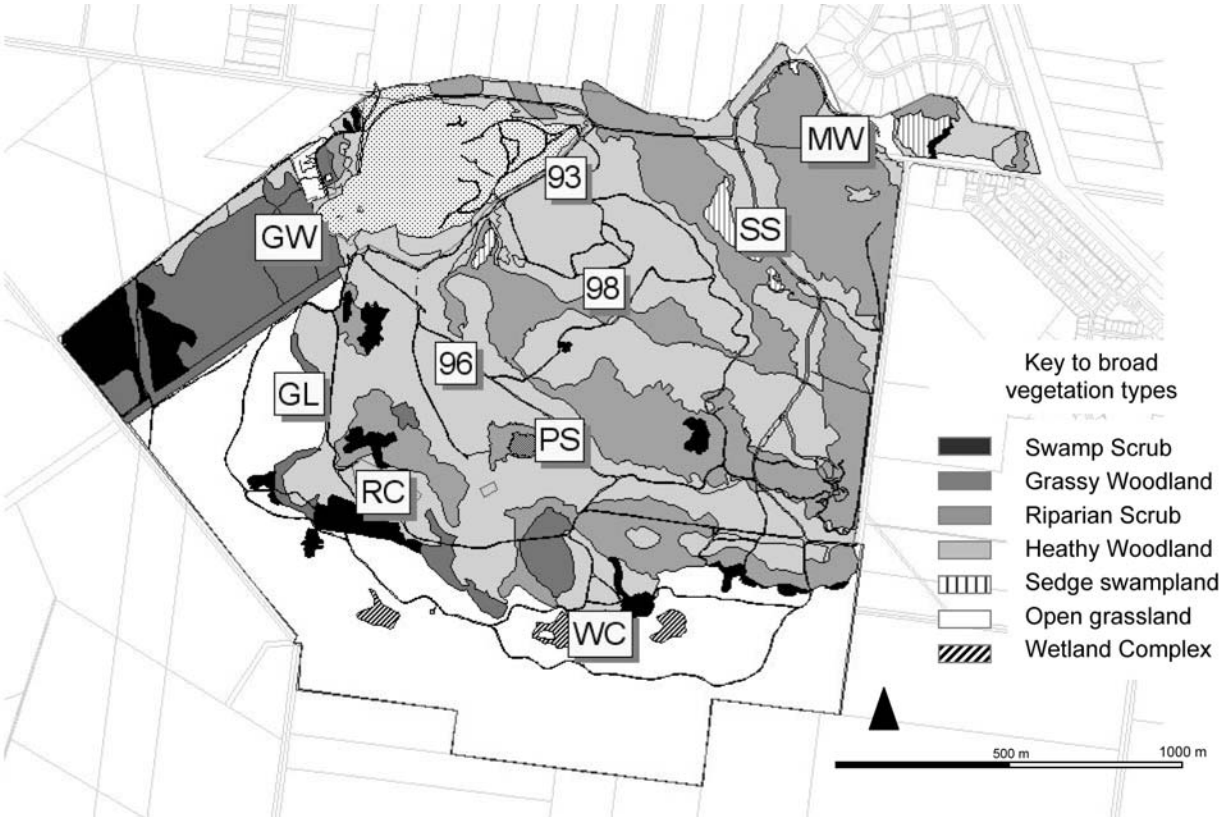

Figure 1. *Map of Royal Botanic Gardens Cranbourne showing location of bird survey sites and the distribution of broad vegetation types (RBGC unpublished data). Key to survey site codes: 93 = heathy woodland burnt in 1993, 96 = heathy woodland burnt in 2996, 98 = heathy woodland burnt in 1998, SS = sedge wetland, MW = Melaleuca Wetland, GW = grassy woodland, GL = grassland, RC = research collection, PS = perched swamp, WC = Wylie's Creek.*

conserve local bird communities (Radford and Bennett 2005; MacHunter *et al*. 2006). It is now unclear whether the fragments of indigenous vegetation remaining in the Melbourne Region are capable of sustaining relatively complete indigenous bird communities in the long term.

The Royal Botanic Gardens Cranbourne (RBGC) contains one of the largest patches of indigenous vegetation remaining in the Melbourne Region and includes high quality examples of a number of vegetation communities that were widespread in the region prior to European settlement (Oates and Taranto 2001). Bird observers, naturalists and researchers have been visiting the site for more than 60 years, recording a large and diverse avian community, including many species that are now threatened in Victoria. Several systematic bird censuses have been conducted at the site since it was acquired by the Royal Botanic Gardens in 1970, providing detailed inventories of the bird community at various times. Remnant vegetation at the RBGC is identified as important for the conservation of a range of state and regionally significant flora and fauna species and requires ongoing monitoring to assess how effectively it performs in its conservation role. In this paper we attempt to document the bird community that persists at the RBGC by systematically recording bird species throughout the site over an extended period. Records from the current study will be used to examine trends in individual species found at the site including a detailed comparison with a similar study conducted between 1989 and 1992. The paper also attempts to identify the parts of the site used by different bird species and the times of the year that they occur there and includes an assessment of the impact development of horticultural collections and wetlands have had on the avian fauna. The data will provide a valuable record of existing avian diversity and inform future management of the site.

METHODS

Study Area

The Royal Botanic Gardens Cranbourne is located 44 kilometres south-east of Melbourne and includes a 250 hectares stand of remnant vegetation, comprising a range of ecological communities that were widespread in the region prior to European settlement. Most of the site supports a variety of 'heath' dominated vegetation communities that have developed on drought-prone, nutrient-poor aeolian sand dunes. Grassy woodlands and swamp scrubs have formed where the aeolian sand is thin or absent and the underlying heavy clay loams approach the surface. A range of wetland communities occur throughout the RBGC in low-lying areas or where impermeable subsurface layers hold water in perched water-tables. In the mid-1990 a series of artificial lakes were constructed in the southern part of the RBGC along an ephemeral drainage line known locally as Wylie's Creek. The RBGC also contains approximately ten hectares devoted to living collections of non-indigenous Australian flora.

As a result of the extensive clearance of indigenous vegetation in the region, the RBGC is now widely recognised as a site of state

conservation significance. Remnant vegetation at the site is managed predominantly for biodiversity conservation and the RBGC has implemented a range of management strategies to deal with specific threats to biodiversity including inappropriate fire regimes, environmental weeds and pest animals. Prior to the first portion of the site being acquired by the Royal Botanic Gardens Melbourne in 1969, parts of the RBGC were used for agricultural production, sand and soil extraction, gold mining and military training. A range of ecological surveys and research has been conducted at the RBGC by scientists, bird observers and other amateur field naturalists dating back to the 1930s.

Bird Survey Sites

Bird surveys were conducted on ten, two-hectare sites at the RBGC between January 1999 and December 2004 (Fig. 1). The sample sites were selected to reflect a range of different habitat types available at the RBGC. Surveys were normally conducted on one day per month between 0730 and 1030 hours. During each survey volunteers from Birds Australia recorded all bird species seen or heard at each site during a 20-minute period, following the standard protocols of Barrett *et al*. (2003). Surveys were conducted by teams of two or more experienced, regular volunteers. All monthly presence/absence records were submitted for inclusion in the Bird Atlas of Australia database (Birds Australia) and compiled extracts from the database were used in the analysis. Nomenclature follows Christidis and Boles (1994). All scientific names of birds are listed in Appendix 1.

In addition to site-specific surveys, all birds seen or heard during the survey period outside the two-hectare sites were recorded. While these are referred to as 'incidental' records throughout this report, the records approximate a small (500 m) area search (*sensu* Barrett *et al*. 2003) across the entire site conducted concurrently with the two-hectare surveys. A departure from the standard Bird Atlas procedure was that birds flying over a site were only recorded within the site if there was a definite association. For example, a Swamp Harrier hunting over the Sedge Swampland site was included as part of that site count but Pacific Gulls flying over to the nearby waste disposal site were counted only as incidental sightings. The ten survey sites comprised:

Heathy Woodland

Three sites containing heathy woodland vegetation were surveyed throughout the study. All heathy woodland sites were in various stages of regrowth following ecological burns implemented by RBGC management. One of the areas was burnt in March 1993 (93 site) and therefore was approximately six years post-fire at the start of the survey and 12 years post fire at the end of the survey. Similarly, the survey tracked bird populations from 2–8 years post fire in an area burnt in December 1996 (96 site) and 0–6 years post-fire in an area burnt in April 1998 (98 site). Heathy woodland sites included areas with close affinity to Heathy Woodland Ecological Vegetation Class (EVC) but may sometimes approximate Sand Heathland , Damp Heathy Woodland or Wet Heath EVCs (Oates and Taranto 2001). Sites consisted of a very sparse to mid-dense canopy of Coast Manna Gum (*Eucalyptus viminalis ssp. pryoriana*), although this was sometimes replaced by Mealy Stringybark (*E. cephalocarpa*) on lower slopes and gullies. The shrub layer is often dense and dominated by Silky Tea-tree (*Leptospermum myrsinoides*) and Prickly Tea-tree (*L. continentale*). Common Heath (*Epacris impressa*), Common Beard-heath (*Leucopogon virgatus*), Common Aotus (*Aotus ericoides*), Prickly Broom-heath (*Monotoca scoparia*) occur as frequent subdominants. The 1993 site was surveyed on 60 occasions, the 1996 site on 56 occasions and the 1998 site on 59 occasions.

Melaleuca Wetland

The *Melaleuca* Wetland site comprised a dense thicket of scrub that occurred in a drainage line between two low dune rises. The vegetation has close affinities with Wet Heath EVC and Riparian Scrub EVC (Oates and Taranto 2001). The tree layer of this site consisted of a very sparse canopy of Mealy Stringybark. The shrub layer is dense and dominated by Scented Paperbark (*Melaleuca squarrosa*) and Prickly Tea-tree. Scrambling Coral-fern (*Gleichenia microphylla*) is a common component of the community, forming dense thickets in places. The ground layer varies from a sparse cover of bryophytes to a dense cover of sedges, most frequently Red-fruit Saw-sedge (*Gahnia sieberiana*), Spreading Rope-rush (*Empodisma minus*), Zig-zag Bog-sedge (*Schoenus brevifolius*), and Pithy Sword-sedge (*Lepidosperma longitudinale*). The *Melaleuca* Wetland site was surveyed on 61 occasions.

Grassy Woodland

The Grassy Woodland site consisted of an open-woodland dominated by Narrow-leaf Peppermint (*Eucalyptus radiata*) and Black Wattle (*Acacia mearnsii*) over an open, grassy understorey. Swamp Gum (*Eucalyptus ovata*), Mealy Stringybark and Coast Manna Gum also occur in places. The shrub layer was typically sparse and consisted largely of Prickly Tea-tree and Hedge Wattle (*Acacia paradoxa*). The ground cover was dominated by monocotyledons, with a range of exotic and indigenous grasses forming the bulk of the biomass. Common Raspwort (*Gonocarpus tetragynus*), Wattle Mat-lily (*Lomandra filiformis*) and Small Poranthera (*Poranthera microphylla*) occur frequently in this stratum. Austral Bracken (*Pteridium esculentum*) occasionally forms dense swards on low sandy knolls that occur sporadically throughout the site. The Grassy Woodland site was surveyed on 65 occasions.

Perched Swamp

The perched swamp site consisted of an ephemeral shallow freshwater marsh that supports a community approximating Aquatic Herbland EVC (Oates and Taranto 2001). This site is often continuously wet or dry for extended periods. At the start of the study the swamp had contained water for the previous five years but it dried out during 2001 and remained dry for the rest of the study. Vegetation of the site was dominated by emergent species such as Water Ribbons (*Triglochin procera*) and Running Marsh-flower (*Villarsia exaltata*) growing on a peaty substrate. The wetland was surrounded by a dense thicket of wet heath. The perched swamp site was surveyed on 52 occasions.

Sedge Swampland

The sedge swampland site consisted of a broad, shallow ephemeral freshwater marsh that rarely contained areas of open water during the current study. Vegetation consisted of a dense, open sedgeland mostly lacking trees or shrubs. Sedges formed a dense sward dominated by Pithy Sword-sedge (*Lepidosperma longitudinale*). A number of other sedges and rushes including Zig-zag Bog-sedge (*Schoenus brevifolius*), Square Twig-sedge (*Baumea tetragona*) and Heron Bristle-sedge (*Chorizandra cymbaria*) occur sporadically. Dark Swamp Wallaby-Grass (*Amphibromus recurvatus*) is sparsely distributed throughout the community. Running Marsh-flower occurred patchily in wetter areas. The community lacked a tree layer and has a sparse shrub layer of emergent Prickly Tea-tree and Scented Paperbark. The sedge swampland site was surveyed on 59 occasions.

Grassland

The grassland site consisted of an area of anthropogenic pasture containing only scattered native trees, many of which had been planted by RBGC staff over the previous 15 years. The area had been cleared of native vegetation for more than 50 years and had been used to graze cattle until the 1990s. The grassland occurred on clay loam soils and was dominated by exotic grasses such as Sweet Vernal-grass (*Anthoxanthum odoratum*), Brown-top bent (*Agrostis capillaris*), Paspalum (*Paspalum dilatatum*) and Yorkshire fog (*Holcus lanatus*). Indigenous grasses such as *Austrodanthonia laevis, Austrodanthonia pilosa, Notodanthonia semiannularis*, and *Hemarthria uncinata* occurred patchily throughout the site. The site was normally slashed and the thatch bailed between December and January each year.

Research Collection

The research collection site contained an area that had been extensively sand-mined during the 1960's and had subsequently been planted with a diverse collection of non-indigenous, proteaceous Australian plants including *Banksia* spp. *Persoonia*

ssp, *Petrophile* spp. *Grevillea* spp. and *Dryandra* spp. Most of the collection was planted by volunteers from the Society for Growing Australian Plants (SGAP) during the early 1980s. Bird surveys were conducted on 28 occasions at the Research Collection site from July 1999 to May 2003.

Wylie's Creek Wetlands

The Wylie's Creek Wetlands site consisted of a regulated open-water dam fringed by a variety of sedges, rushes and grasses and thickets of Swamp Paperbark (*Melaleuca ericifolia*). The dam was the largest of four similar water bodies constructed along an ephemeral watercourse known locally as Wylie's Creek during the mid 1990s. The wetland extended over an area of approximately 1.5 hectares and continuously held water throughout the period of the study. Surveys were conducted on 53 occasions at the Wylie's Creek site from November 1999 to December 2004.

Data treatment

All presence-absence data were transformed to a 'reporting rate' index by dividing the number of positive records by the number of surveys conducted (Barrett *et al*. 2003). This index expresses the proportion of surveys from a particular category when a species was detected. The reporting rate index effectively reflects the probability that a species will be recorded in a particular site or at a particular time and which is therefore correlated with the abundance of the species (Bart and Klosiewski 1989; Barrett *et al*. 2003; Radford *et al*. 2005). Reporting rates are widely used to describe spatial and temporal variation in bird abundance (Barrett *et al*. 2003; Roberts *et al*. 2007). While this is complicated by factors that affect the detectability of the species, it is presumed here that the reporting rate reflects the relative abundance of species because sampling effort is held fairly constant throughout the surveys. For site comparisons the total number of surveys at each site over the duration of the study was used to calculate a site-specific reporting rate for each species. Because the reporting rate is derived from binary data (presence or absence) differences in reporting rate between sites were compared using binary logistic regression in MINITAB v.13. Logistic regression applies maximum likelihood estimation using a logit link function and essentially estimates the likelihood of a species being recorded at each survey site based on independent monthly samples. A log-likelihood (G) test was used to test the null hypothesis that the likelihood of recording a species did not differ significantly between sites.

Reporting rate data for each species were analysed for temporal trends using a non-parametric runs test (Sokal and Rohlf 1995). This test indicates whether ordered data, in this case sequential monthly reporting rates for each species, occur in significantly non-random sequences above or below the mean value. Analysis was performed using MINITAB v.13. Only species with greater than ten records were included in the analysis. Significantly non-random patterns were then assessed subjectively to identify whether the likely source of the significant 'run' was cyclic (seasonal or annual) or monotonic (increasing or decreasing). All significant runs were described subjectively based on the form of the plotted data.

Between September 1989 and December 1992, monthly bird surveys were conducted at the RBGC by volunteers from the Bird Observers Club of Victoria (BOCA 1993; Evans and Kloot 1993). In 40 consecutive months, teams of observers recorded all birds seen throughout the site over a period of approximately four hours on a single day. The records were converted to a standard reporting rate by dividing the number of monthly records for each bird species by the number of surveys conducted (n = 40). These surveys are analogous to the Barrett *et al*. (2003) small area search method and are comparable to the incidental data collected during the 67 monthly surveys conducted during the present study. Although there were some minor differences in the survey methods, both are assumed to represent a site-wide sample conducted by a medium sized group of bird observers on a single morning each month. Because reporting rates are the proportion of monthly surveys when a species was detected, statistical comparisons between the 1989–92 survey and the current survey used a 2-proportions test (Z-test) in MINITAB V13.

RESULTS

The RBGC Bird Community

A total of 150 native and ten introduced species of bird were recorded at the RBGC between January 1999 and December 2004 (Appendix 1). Of all the species recorded, 119 were recorded within the ten, two-hectare study sites and 157 were recorded as incidental records. The most frequently recorded species throughout the survey period were New Holland Honeyeater, White-browed Scrubwren, Grey Fantail, Red Wattlebird, Brown Thornbill, White-eared Honeyeater and Grey Shrike-thrush all of which were recorded in more than 40 per cent of all surveys. Eighteen species (11%) were recorded on only a single occasion.

It was common for bird species to be recorded at few if any of the defined survey sites. Ninety-two species (57%) were recorded at two or fewer sites and included 41 species that were not recorded in any of the ten defined sample sites. For the most part this pattern could probably be attributed to the small number of records for many species rather than an obvious preference for a particular site. By contrast, 38 species (24%) were recorded at nine or ten sites and were considered to be widespread at the RBGC. The most widespread species included Red Wattlebird, Eastern Rosella, New Holland Honeyeater, Grey Fantail and Mistletoebird.

TABLE 1

Summary of bird species richness at ten survey sites at the Royal Botanic Gardens Cranbourne, 1999-2004. Unique species are those that were not recorded at any other site. Key to survey site codes: 93 = heathy woodland burnt in 1993, 96 = heathy woodland burnt in 1996, 98 = heathy woodland burnt in 1998, GW = grassy woodland, GL = grassland, MW = *Melaleuca* Wetland, SS = sedge wetland, PS = perched swamp, WC = Wylie's Creek, RC = research collection site.

	Survey Sites										Total
	98	96	93	GW	GL	MW	SS	PS	WC	RC	
Total number of species recorded	59	60	61	63	51	57	54	52	83	36	119
Average number of species per survey (± SE)	10.34±0.52	9.48±0.61	9.1±0.43	15.34±0.61	6.7±0.46	11.19±0.51	8.08±0.53	6.09±0.40	14.92±0.75	6.78±0.47	–
Maximum number of species recorded	22	22	16	29	14	20	19	15	29	13	29
Number of unique species	3	1	0	4	2	3	1	0	20	0	34
Number of surveys	59	56	60	65	51	61	59	52	53	28	544

TABLE 2

Reporting rates for introduced bird species in ten survey sites at the Royal Botanic Gardens Cranbourne from 1999-2004. Percentage of monthly surveys in which each species was recorded in each survey site throughout the study. S = species showing statistically significant differences in reporting rate between survey sites ($P<0.05$). INC = proportion of monthly surveys where the species was recorded as an incidental observation. Key to survey site codes: 93 = heathy woodland burnt in 1993, 96 = heathy woodland burnt in 1996, 98 = heathy woodland burnt in 1998, GW = grassy woodland, GL = grassland, MW = *Melaleuca* Wetland, SS = sedge wetland, PS = perched swamp, WC = Wylie's Creek, RC = research collection.

Species		**98**	**96**	**93**	**MW**	**SS**	**PS**	**GL**	**GW**	**RC**	**WC**	**S**	**INC**
Rock Dove	*Columba livia*	0	0	0	0	0	0	0	0	0	0	–	11.9
Spotted Turtle-Dove	*Streptopelia chinensis*	4.1	2.8	2.8	30.5	16.6	8.2	8.3	20.8	20	8.1	–	74.6
Skylark	*Alauda arvensis*	0	0	0	0	0	0	1.96	0	0	5.88	–	22.4
House Sparrow	*Passer domesticus*	0	0	0	0	0	0	0	1.3	0	0	–	35.8
European Goldfinch	*Carduelis carduelis*	2.7	2.7	11.1	22.2	5.5	3.2	0	2.7	44.4	30.6	–	46.3
Common Blackbird	*Turdus merula*	4.1	4.1	11.1	30.5	8.33	6.5	16.7	45.8	6.7	19.3	√	67.2
Song Thrush	*T. philomelos*	0	0	0	1.4	0	0	0	1.3	0	0	–	7.5
Common Starling	*Sturnus vulgaris*	1.3	6.9	6.9	19.4	27.8	21.3	29.1	9.7	6.7	48.4	√	82.1
Common Myna	*Acridotheres tristis*	2.7	8.3	8.3	47.2	31.9	6.5	54.2	55.5	6.7	41.9	√	83.6
Number of surveys		59	56	60	61	59	52	51	65	28	53	–	67
Reporting rate for 'exotic species'		1.75	3.5	5.2	15.9	13.6	8.9	22.5	9.9	13.1	11.6	–	95.5

TABLE 3

Patterns of temporal change in reporting rates of bird species at the Royal Botanic Gardens Cranbourne, 1999-2004. Only species demonstrating statistically significant 'runs' above or below the median monthly reporting rate are included in the table. The deviation type and description identify the general type of pattern observed in the data. Seasonal deviation identifies those species with reporting rates that change during the year, annual deviations identify species with the reporting rate that changed between years but which were similar at the beginning and end of the study. Trend patterns identify those where reporting rates were higher or lower at the end of the study than at the start of the study. Temporal patterns for individual species are described subjectively according to the timing of periods of high or low reporting rates.

Species	P	Deviation Type	Description
Blue-billed Duck	0.000	Trend	High later in study
Pacific Black Duck	0.002	Seasonal	Spring high
Grey Teal	0.001	Seasonal	Autumn-Winter absent
Chestnut Teal	0.000	Seasonal/Trend	Spring high. High later in study
Hardhead	0.031	Seasonal	Spring high
Australasian Grebe	0.001	Annual	Low 2002–2003
Hoary-headed Grebe	0.001	Trend	High later in study
Great Cormorant	0.003	Trend	Low later in study
Australian White Ibis	0.008	Seasonal	Spring high
Straw-necked Ibis	0.009	Seasonal	Spring high
Swamp Harrier	0.004	Seasonal	Autumn-winter low
Purple Swamphen	0.037	Annual	High 2001
Eurasian Coot	0.030	Annual	High 2001
Brush Bronzewing	0.008	Seasonal	Winter low
Pallid Cuckoo	0.000	Seasonal and Trend	Absent winter. Low later in study
Fan-tailed Cuckoo	0.031	Seasonal	Spring high
Horsefield's Bronze-Cuckoo	0.000	Seasonal	Spring high
Shining Bronze-Cuckoo	0.000	Seasonal	Spring high
Yellow Thornbill	0.000	Trend	High later in study
Red Wattlebird	0.032	Seasonal	Autumn low
Yellow-faced Honeyeater	0.000	Seasonal	Winter low
White-naped Honeyeater	0.038	Seasonal	Winter low
Rufous Whistler	0.001	Seasonal	Summer high-winter low
Satin Flycatcher	0.000	Seasonal	Summer high
Grey Fantail	0.034	Seasonal	Winter low
Australian Magpie	0.019	Annual	High 2001–2002
Richard's Pipit	0.002	Seasonal	Winter low
European Goldfinch	0.000	Seasonal	Late autumn low-spring high
Welcome Swallow	0.010	Seasonal	Autumn high
Tree Martin	0.045	Seasonal	Autumn high
Clamorous Reed-Warbler	0.000	Seasonal	Winter absent
Golden-headed Cisticola	0.000	Unclear	–
Common Starling	0.000	Seasonal	Summer high

The Grassy Woodland site had the highest average number of species per survey of any of the sites (Table 1). However, the largest total number of species was recorded at Wylie's Creek Wetlands with 83 species recorded during 53 systematic surveys. This site contained many species that were not recorded at other sites and included a number of common waterbirds (e.g. Purple Swamphen, Eurasian Coot, Dusky Moorhen, and Australasian Grebe). The poorest sites were the Perched Swamp, Research Collection and Grassland sites all of which had an average survey richness of less than seven species per sample. The remainder of sites recorded around 60 species over the duration of the study at an average of 8–11 per sample (Table 1).

Site Preferences

Thirty-one of the native species recorded during the study showed a statistically significant difference in reporting rate between sample sites (Appendix 1). A much larger group appeared to be recorded in relatively high or low proportion of the surveys at some sites but the differences were commonly not statistically significant, possibly due to low sample size or the absence of records from other sites. This was most evident in the Wylie's Creek Wetlands site where many species were either unique to the site or were rarely recorded at other sites. Preferences by birds for other sites were generally less pronounced, with many species occurring at all or most sites but being more or less frequently recorded at some sites compared

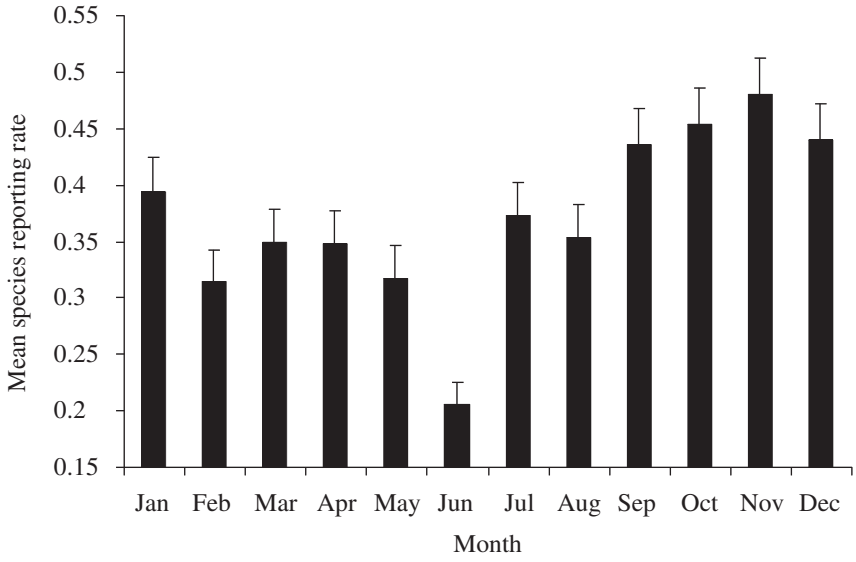

Figure 2. *Average monthly reporting rates (±SE) for all bird species recorded at the RBGC, 1998-2004. Average values have been calculated using the monthly incidental reporting rates for 160 species.*

with others. For example, Brush Bronzewing, Eastern Rosellas, White-browed Scrubwrens and pardalotes were more likely to be recorded at heathy woodland sites but still occurred at most other sites. By contrast, Swamp Harriers and Silvereyes were more often recorded at two shallow freshwater marsh sites (*Melaleuca* Wetland and Sedge Swamp) than at drier, wooded sites. Welcome Swallows were more likely to be recorded at open sites where water was present and were relatively rare in areas of woodland while Rainbow Lorikeet, Brown Thornbill, Laughing Kookaburra, White-naped Honeyeater and White-plumed Honeyeater were all more likely to be seen at the Grassy Woodland site than other sites. Indeed, Laughing Kookaburras appeared to be largely confined to sites with open ground layers. Silvereyes, Yellow-faced and White-eared honeyeaters tended to be uncommon at sites with lower levels of tree cover.

While many species were more likely to be recorded in areas of natural vegetation, many others favoured areas that had been extensively modified. These included species such as Magpie-lark, Australian Magpie and Yellow-rumped Thornbill, all of which were more commonly seen in areas dominated by anthropogenic grassland. Willie Wagtails also tended to be much more common at or near modified, open sites and were generally uncommon in areas of 'natural' vegetation. The most widespread bird during the study, the New Holland Honeyeater was less likely to be seen at the sites where clay loam soils were found.

Five common introduced bird species were recorded at all survey sites at the RBGC. Three of these (Spotted Turtle-Dove, Common Myna and Common Starling) were amongst the most frequently encountered species recorded during the study (Table 2). A further five introduced species were rarely recorded at any of the defined survey sites. The largest number of exotic bird species recorded at a site during any single survey was five at Grassy Woodland in October 2003. Highest reporting rates for many exotic species occurred in the Grassy Woodland, Wylie's Creek Wetlands and *Melaleuca* Wetland sites, but exotic species typically represented a higher proportion of the total bird fauna at highly modified sites compared with 'natural' sites. Introduced species were generally unlikely to be seen in heathy woodland sites, particularly those that had been burnt recently (Table 2). Common Blackbird, Common Myna and Common Starling showed distinct preference for sites with a grassy ground cover (Grassy Woodland, Grassland and Wylie's Creek Wetlands).

Temporal change

It was clear that the composition of the bird community at the RBGC varied throughout the study. Of the 89 species with sufficient records for analysis (>10 records), 33 (37%) showed significant runs of above or below average monthly recording rates ($P < 0.05$, Table 3). The main source of non-random patterns appeared to be associated with seasonal differences in reporting rate (Table 3). Bird species richness increased and decreased predictably on an annual cycle with the highest number tending to occur in late spring-early summer and the lowest number in winter. The number of species recorded in winter surveys was generally about 30–40 species while in summer 70–80 species were typical. The maximum number recorded in any monthly sample was 92 species in November 2004. The lowest number of species recorded in any month was 29 in August 2003. These changes in total species richness could be attributed to seasonal differences in either abundance or detectability, with the main pattern being an increase in reporting rates during surveys conducted in spring and early summer. Seventy per cent of the species recorded were most likely to be reported in surveys during the later part of the year, between August and December and this is reflected in the average monthly reporting rate for all species (Fig. 2). Although there was evidence that some species had their highest reporting rates in months from January to July, these represented only a relatively small proportion of the species recorded during the study.

Not all of the changes in reporting rates could be attributed to seasonal factors. In a small group of species, reporting rates appeared to be either higher or lower than average in some years of the study (Table 3). While some species had relatively high or low reporting rates during the middle years of the study, there was also some indication of longer-term population trends in some species over the course of study. In addition, a number of species such as Bell Miner, Latham's Snipe, Australasian Shoveler, Little Corella, Scarlet Robin, Dusky Moorhen, Brown Goshawk and Song Thrush were frequently recorded during the later years but had been rarely recorded during the early part of the study. By contrast, Noisy Miners were not recorded during the later years of the study whereas they were regularly recorded during the early years of the study. In many cases populations of these birds were small and changes in reporting rate might conceivably be attributed to the arrival or loss of individual birds or pairs.

Comparison with 1989–1992 Survey

Thirty-two bird species (20% of total) were recorded at a significantly higher rate during the current survey than in the 1989–1992 BOCA survey (Table 4). The majority of these increasing species (n = 22) were primarily associated with wetland areas and included species of ducks, grebes and crakes. Six of the species had not been recorded at all during the earlier survey yet were recorded in more than 20 per cent of the monthly surveys during the present study. There was also evidence of modest increases in the reporting of some raptors and nectivorous species. Reporting rates for Rainbow Lorikeets increased dramatically between the two surveys. This species was recorded in the majority of months in the current study after having not been recorded in any monthly surveys between 1989 and 1992. By contrast, nine species were recorded at a significantly lower rate in the current survey than in 1989–92. These included a group of 'pest' species such as House Sparrow, Skylark, Rock Dove and Noisy Miner. Two species of gull and Australian Pelicans were also, perhaps surprisingly, less commonly reported in the current study than previously.

DISCUSSION

The results of this study demonstrate that the Royal Botanic Gardens Cranbourne supported a rich bird community between 1999 and 2004. Prior to 1999, 146 bird species had been recorded from the site (DSE 2007; RBG unpublished data) and the majority of these species were also recorded during the current survey. This result suggests that during the period of the survey the RBGC continued to provide suitable habitat for most indigenous bird species known from the site. The 19 species recorded prior to 1999 that were not recorded during this study included a number species that had only been recorded on one or two previous occasions and may be either uncommon in the region or difficult to detect using the techniques employed here. Species in this category include nocturnal species (e.g. Powerful Owl, Barn Owl), unusual, rare or vagrant species (Tree Sparrow, Rufous Songlark, Eastern Curlew, Whiskered Tern, Glossy Ibis, Royal Spoonbill, Pied Cormorant, Spotted Harrier, Grey Goshawk, White-bellied Sea-eagle, Swift Parrot and European Greenfinch) or species at the edge of their geographic range (Red-rumped Parrot, Singing Honeyeater, Weebill, Singing Bushlark).

A large proportion of the native species known from the south central region of Victoria have now been recorded at the RBGC. Excluding predominantly marine species, 188 species of bird had been recorded in the ten-minute grid block (269 km^2) in which the site is located (DSE 2007; unpublished data). Of these species, 85 per cent were recorded at the RBGC during the current survey. Even at a larger scale the site makes a substantial contribution to native bird conservation. More than 60 per cent of the terrestrial and aquatic species ever recorded in the extensive Gippsland Plains Bioregion were recorded at the RBGC during the current survey (DSE 2007; unpublished data). The bird community included a group of species that appeared to be rare or restricted in the greater Gippsland Plains Region during roughly the same period (1997-2002; Radford and Bennett 2005). The bird fauna of the RBGC also included at least thirty-two species now officially identified as either threatened at a state level or considered to be of conservation concern in the greater Gippsland Plains Region (DSE 2003; Radford and Bennett 2005). The results suggest that the RBGC provides resources for a large proportion of the bird species of the region and contributes to the conservation of avifauna at a regional and state level. In contrast, MacHunter *et al*. (2006) reported a dramatic decline in bird species richness in small to medium sized vegetation remnants elsewhere in the Gippsland Plains Bioregion over a comparable period.

While the avifauna at the site was species-rich, some bird species that occur widely in the Gippsland Plains Bioregion were rare or absent at the RBGC. Eleven of the 108 terrestrial species considered by Radford and Bennett (2005) to be typical of the greater Gippsland Plains have never been recorded at the RBGC, namely the Eastern Whipbird, Crescent Honeyeater, Pied Currawong, Gang-gang Cockatoo, Jacky Winter, Olive Whistler, White-throated Nightjar, Red-browed Treecreeper, Beautiful Firetail, Pilotbird and White-winged Chough. The greater Gippsland Plains Region considered by Radford and Bennett (2005) included the Strzelecki Ranges, which are technically part of the Victorian Highlands-Southern Fall Bioregion (NRE 1997) and many of the species 'missing' from the RBGC either have a rare and restricted distribution in the region or are more typical of forest habitats that occur in the ranges rather than the plains.

However, some species that might be expected to occur were not recorded during the current survey and appear to be under-represented at the site. Jacky Winters are widespread elsewhere but may be sensitive to patch size (Martin and Catterall 2001) and the fragmented habitat remaining in the Melbourne Region may not now provide them with suitable habitat. Similarly, White-fronted Chats are widespread in the greater Gippsland Plains Region (Radford and Bennett 2005) and their absence from the current survey may be symptomatic of a general decline throughout south-eastern Australia in recent decades (Olsen *et al*. 2003). In contrast, species such as the Crested Pigeon, Little Lorikeet, Galah and Noisy Miner are now common and increasing in the suburbs south-east of Melbourne, yet were uncommon at the RBGC during the current survey. The Crested Pigeon and Little Lorikeet are generally dry-country species still uncommon in the Gippsland Plains Region (Radford and Bennett 2005). Both species may increase in abundance as the area around the RBGC urbanises.

TABLE 4

Comparison of reporting rates of bird species at the RBGC during the present survey with a similar conducted between 1989 and 1992. Reporting rate comprises the proportion of months surveyed where a species was recorded anywhere at the RBGC. Only those species where differences in the reporting rate between the two surveys were statistically significant are included (Z-test, $P<0.05$).

Species	Reporting rate 1989-1992 (N=40)	Reporting rate 1998-2004 (N=70)	Increase (I) or Decrease (D)	Explanation
Blue-billed Duck	0.00	0.34	I	Wetland development
Black Swan	0.00	0.17	I	Wetland development
Australian Wood Duck	0.15	0.62	I	Wetland development
Pacific Black Duck	0.55	0.86	I	Wetland development
Australasian Shoveler	0.00	0.11	I	Wetland development
Grey Teal	0.00	0.23	I	Wetland development
Chestnut Teal	0.00	0.58	I	Wetland development
Hardhead	0.00	0.51	I	Wetland development
Australasian Grebe	0.08	0.63	I	Wetland development
Hoary-headed Grebe	0.00	0.66	I	Wetland development
Darter	0.00	0.08	I	Wetland development
Australian Pelican	0.73	0.24	D	Survey methodology; external factors
White-faced Heron	0.20	0.39	I	Wetland development
Swamp Harrier	0.58	0.77	I	Grassland expansion
Wedge-tailed Eagle	0.03	0.11	I	Grassland expansion
Little Eagle	0.05	0.13	I	Grassland expansion
Peregrine Falcon	0.00	0.24	I	?
Baillon's Crake	0.00	0.14	I	Wetland development
Australian Spotted Crake	0.00	0.13	I	Wetland development
Purple Swamphen	0.20	0.85	I	Wetland development
Dusky Moorhen	0.03	0.75	I	Wetland development
Eurasian Coot	0.00	0.79	I	Wetland development
Latham's Snipe	0.00	0.17	I	Wetland development
Masked Lapwing	0.48	0.70	I	Wetland development; grassland expansion
Silver Gull	0.78	0.20	D	Survey methodology; external factors
Pacific Gull	0.65	0.35	D	Survey methodology; external factors
Rock Dove	0.30	0.1	D	?
Little Corella	0.00	0.14	I	Nectar availability
Rainbow Lorikeet	0.00	0.62	I	Nectar availability
Yellow-rumped Thornbill	0.23	0.54	I	Grassland
Little Wattlebird	0.58	0.93	I	Nectar availability
Bell Miner	0.00	0.21	I	Range expansion? Habitat degradation
Noisy Miner	1.00	0.07	D	?
Eastern Spinebill	0.20	0.46	I	Nectar availability
Varied Sitella	0.53	0.28	D	?
Willie Wagtail	1.00	0.83	D	?
Grey Butcherbird	0.55	0.80	I	?
Australian Raven	0.58	0.79	I	External factors
Skylark	0.55	0.32	D	?
House Sparrow	0.55	0.38	D	?
Clamorous Reed-Warbler	0.05	0.42	I	Wetland development
Little Grassbird	0.03	0.32	I	Wetland development
Golden-headed Cisticola	0.08	0.51	I	Wetland development

While some species were not detected during the current survey, a notable feature of the study is that the bird community at the RBGC now appears richer than was previously known. In 40 monthly surveys conducted from 1989 to 1992, 121 bird species were recorded. In the 67 monthly surveys of the current study, the number of species recorded at the site increased by more than 30 per cent. No doubt some of the increased number of taxa known from the site can be attributed to the cumulative increase in survey effort that accompanied the current survey. Increasing survey effort is likely to result in more species being recorded if other factors remain constant (Mac Nally and Horrocks 2002). Therefore, as surveys continue more species are likely to be added to a list, albeit at a diminishing rate. However, there was a clear indication that reporting rates for many species were higher during the current survey than previously, suggesting that some populations have increased. (The larger number of indigenous species that were recorded may also reflect an increase in the diversity of habitats available for birds at the RBGC.)

The most obvious difference in the bird fauna between this study and previous records was an increase in the reporting rates of many wetland dependant species. Several waterbirds were commonly recorded in the current survey but were either absent or uncommon at the site between 1989 and 1992 (Evans and Kloot 1993). This change may stem from an increase in suitable habitat resulting from the construction of wetlands at the site during the mid 1990s. Although open water wetlands occurred at the site in the past, deep permanent wetlands such as those that occurred at Wylie's Creek Wetlands were not present when previous surveys were conducted. Furthermore, the current study was conducted during an extended period of below average rainfall and presence of permanent water through a period of local drought may have also contributed to the increase in species richness at the site. A number of species have probably also been favoured by the expansion of reedbeds and grass swards associated with the wetland developments (e.g. Golden-headed Cisticola, Little Grassbird, Yellow-rumped Thornbill, Little Corella). While the greater likelihood of recording these taxa is consistent with an increase in habitat diversity, it is possible that other factors may have contributed to the apparent growth in some populations. For instance, larger-bodied waterbirds may have benefited disproportionately from lower numbers of Red Foxes (*Vulpes vulpes*) present at the site since 2001 (Coates unpublished data).

Two nectivorous species, Bell Miner and Rainbow Lorikeet, were more likely to be recorded at the site during the current survey than previously. Bell Miners have increased in range and abundance elsewhere in eastern Australia in recent decades and potentially threaten bird diversity and community health (Wardell-Johnson *et al*. 2006). There is reason for concern that the recent appearance of the colonies at the RBGC may be indicative of range expansion and the species may continue to spread to new locations within the site or elsewhere in the region. Rainbow Lorikeets were considered to be uncommon or absent at the RBGC in surveys conducted prior to 1992 (Simpson 1974; Evans and Kloot 1993; DSE 2007; RBGC unpublished data). By contrast, in the present study Rainbow Lorikeets were recorded at most sites and in most months of the year. This species has increased dramatically in urban areas since the 1970s and the increase in records at the RBGC may indicate a further expansion in range associated with urban development in the region during the last decade. The species' distribution may be tied to the availability of suitable mature flowering eucalypts and suitable species are often available in residential streets and gardens in urban areas (Williams *et al*. 2006). Their increased reporting rate during the current study could also conceivably be linked to the maturing of non-indigenous flowering eucalypts or other species planted at the RBGC or on adjacent properties during the 1980s and 1990s. This factor may also partially account for the apparent increase in some other nectivorous species (e.g. Eastern Spinebill, Little Wattlebird).

Exotic and native pest species were generally uncommon in most parts of the RBGC that supported dense heathy vegetation. Instead these species tended to be concentrated in areas where the understorey was simple and open. Recent studies have shown that exotic species tend to be uncommon in high quality remnant vegetation in the Melbourne Region (Antos *et al*. 2006). Similarly the widespread native species, the Noisy Miner, is also less common in large continuous patches of indigenous vegetation with dense understorey (Loyn 1987; Major *et al*. 2001; Martin and Catterall 2001). The species' abundance has been positively related to low habitat diversity, grazing and other agriculture related indexes (Loyn 1987). Noisy Miners appear to be common and increasing in remnant vegetation throughout eastern Australia including the Gippsland Plains Region (Major *et al*. 2001; Radford and Bennett 2005).

Surprisingly, reporting rates for Australian Pelicans, Pacific Gulls and Silver Gulls were lower in the present study despite the species appearing to be generally common in the region. These species are typically coastal but also commonly occur around high concentrations of anthropogenic waste at council 'tips'. The species were only recorded as 'flying over' in both studies and the change in reporting rate may reflect a difference in counting methods used at the surveys sites. For instance it is possible that the exclusion of 'flying over' species from 20-minute surveys also influenced the rate at which they were recorded incidentally. However, flying over movements might also conceivably be affected by changes in the location of waste facilities and this may account for some of the difference in reporting rates.

A large proportion of the species recorded at the RBGC between 1999 and 2004 appeared to occur widely throughout the vegetated parts of the site. Individual survey sites rarely revealed more than 50 per cent of the total species list but most contributed to the overall richness of birds at the site. However, several of the sites were relatively species-poor and appeared to contribute little to overall species diversity. While this may be understandable at sites with limited structural and floristic complexity (e.g. Grassland and Perched Swamp), it was surprising to us that the Research Collection site supported so few species. Indeed, many otherwise ubiquitous species were conspicuous by their absence and the site was instead dominated by a small number of aggressive nectivores such as Little Wattlebird and New Holland Honeyeater. The site consists of mixture of exotic Australian species including a large range of Proteaceae and potentially contains unique and diverse resources. At the beginning of the study it was thought that the site might also support an unusual and diverse bird community. However, it is possible that the site was defensible by aggressive,

territorial honeyeaters and that these species could effectively exclude other birds. This type of behaviour has been reported previously from a range of sites in south-eastern Australia (Loyn 2002; Caterall 2004; Wardell-Johnson *et al*. 2006).

Several areas contributed disproportionately to the richness of the total bird community at the RBGC. The anthropogenic wetlands constructed in the 1990s appear to have attracted many new species to the RBGC that would otherwise probably be absent. These wetlands now support one of the richest bird communities at the site. Similar increases in bird diversity have been noted elsewhere following the development of wetlands (Fulton 2002). It is also clear from the data presented here that a large proportion of conservation significant species recorded at the site were associated with these wetlands. It is common elsewhere for wetland dependant species to be well represented in threatened species lists (DSE 2003). This is in part due to the dramatic decline in the extent and condition of natural wetland habitats since European settlement (NRE 1997). Natural wetlands at the site tend to be small and/or ephemeral and remained largely dry throughout most of the study. It is possible that the newly constructed permanent wetlands provided a habitat that was rare elsewhere during the period of the study.

The Grassy Woodland vegetation community that occurs at the site also made a disproportionately large contribution to the richness of the local bird community. The Grassy Woodland site recorded the second largest number of unique species (4) and many other species showed significantly higher reporting rates there than at other sites. This community typically forms on relatively fertile clay loam soils and was extensively cleared for agriculture throughout most of the region during the 19th century. The 25-hectare fragment retained in the RBGC is now a relatively rare habitat in the south-central region of Victoria. The vegetation at the survey site is also quite different structurally and floristically from the heathy woodland vegetation that occurs elsewhere at the RBGC. These factors probably contribute to the uniqueness of the Grassy Woodland site. However, the same factors may also contribute to the large number of exotic birds that occured at the site. Common Blackbirds and Common Mynas are both abundant in areas of open woodland at the site and may pose a serious threat to the long-term viability of remnant Grassy Woodland bird communities. Common Mynas occupy natural tree hollows required for successful breeding by many birds and when they occur in high numbers they may pose a serious threat to some native species. (Pell and Tidemann 1997; Tidemann n.d.). When Common Blackbirds occur in high numbers they may harvest large numbers of invertebrates from soil potentially exploiting a scarce resource. Common Blackbirds are also implicated in the spread of major environmental weeds such as Sweet Pittosporum (*Pittosporum undulatum*), which is a potential major threat to grassy woodland vegetation (Carr *et al*. 1992; Mullet and Simmons 1995).

The patterns of both spatial and temporal distribution recorded in the current study were consistent with many previous studies. Variation in reporting rates appeared to be tied to predictable factors such as season or the structure of the vegetation. A large proportion of the species from the site increased and decreased seasonally, most commonly peaking between August and November presumably in response to annual patterns in climate, resource availability or individual species life-histories. This general pattern is typical of sites in south-eastern Australia where species turnover occurs when individual birds migrate north and are replaced by species that migrate from inland or sub-alpine regions to over-winter in lowlands (Emison *et al*. 1987; Loyn 2002). Yet another small group of birds appeared to only arrive in the area in late summer-Autumn, possibly concentrating there during the driest part of the year (e.g. Tree Martin, Musk Lorikeet). Overlaying these predictable patterns were other patterns, apparently less predictable and possibly linked to a suite of other variables that potentially influence the appearance or non-appearance of individual bird species. Some of the variation may be related to longer-term cycles tied to factors such as climate and disturbance but others may be part of longer-term population trends.

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APPENDIX 1

Reporting rates for native bird species in survey sites at the Royal Botanic Gardens Cranbourne from 1998-2004. Table shows the percentage of monthly surveys where each species was recorded. Number of surveys shown in parentheses. S = species showing statistically significant differences in reporting rate between survey sites (logistic regression P70.05). INC = proportion of monthly surveys where the species was recorded as an incidental observation. B = species recorded as breeding at the site during the survey. Key to survey site codes: 93 = heathy woodland burnt in 1993, 96 = heathy woodland burnt in 1996, 98 = heathy woodland burnt in 1998, GW = grassy woodland, GL = grassland, MW = *Melaleuca* Wetland, SS = sedge wetland, PS = perched swamp, WC = Wylie's Creek, RC = research collection site.

Species		Survey Sites (%)												
		98 (59)	96 (56)	93 (60)	MW (61)	SS (59)	PS (52)	GL (51)	GW (65)	RC (28)	WC (53)	S	INC (67)	B
Stubble Quail	*Coturnix pectoralis*							2				–	0	
Brown Quail	*C. ypsilophora*		5.4				1.9					–	3	
Blue-billed Duck	*Oxyura australis*										25.5	–	22.4	√
Musk Duck	*Biziura lobata*											–	3	
Black Swan	*Cygnus atratus*											–	13.4	
Australian Shelduck	*Tadorna tadornoides*										2	–	6	
Australian Wood Duck	*Chenonetta jubata*					3.4		3.9	9.2		29.4	√	28.4	√
Pacific Black Duck	*Anas superciliosa*	1.6		2	16.4	13.6	5.7		4.6		80.4	√	53.7	√
Australasian Shoveler	*A. rhynchotis*											–	11.9	
Grey Teal	*A. gracilis*										9.8	–	14.9	√
Chestnut Teal	*A. castanea*										41.2	–	37.3	√
Pink-eared Duck	*Malacorhynchus membranaceus*											–	1.5	
Hardhead	*Aythya australis*										23.5	–	37.3	
Australasian Grebe	*Tachybaptus novaehollandiae*										52.9	–	35.8	√
Hoary-headed Grebe	*Poliocephalus poliocephalus*										78.4	–	37.3	√
Darter	*Anhinga melanogaster*											–	9	
Little Pied Cormorant	*Phalacrocorax melanoleucos*						1.9				3.9	–	19.4	
Little Black Cormorant	*P. sulcirostris*											–	6	
Great Cormorant	*P. carbo*										3.9	–	16.4	
Australian Pelican	*Pelecanus conspicillatus*											–	25.4	
White-faced Heron	*Egretta novaehollandiae*					1.7	3.8	5.9			5.9	√	28.4	√
Eastern Reef Egret	*E. sacra*										2	–	10.4	
Great Egret	*Ardea alba*											–	4.5	
Intermediate Egret	*A. intermedia*											–	1.5	
Cattle Egret	*A. ibis*											–	1.5	
Nankeen Night Heron	*Nycticorax caledonicus*											–	1.5	
Australasian Bittern	*Botaurus poiciloptilus*											–	1.5	
Australian White Ibis	*Threskiornis molucca*	4.9	1.8	3.9	11.5	3.4	5.7	11.8	12.3		17.7	√	71.6	
Straw-necked Ibis	*T. spinicollis*			2				7.8	1.5		9.8	√	47.8	
Yellow-billed Spoonbill	*Platalea flavipes*											–	6	
Black-shouldered Kite	*Elanus axillaris*		1.8	3.9							2	–	28.4	√
Black Kite	*Milvus migrans*											–	1.5	
Whistling Kite	*Haliastur sphenurus*		1.8									–	17.9	
Swamp Harrier	*Circus approximans*	13.1	1.8	7.8	32.8	39	7.6			3.6	7.8	√	55.2	√
Brown Goshawk	*Accipiter fasciatus*	4.9	1.8	7.8	3.3	5.1	3.8	2	6.2		3.9	–	44.8	
Collared Sparrowhawk	*A. cirrhocephalus*								1.5			–	3	
Wedge-tailed Eagle	*Aquila audax*											–	10.4	
Little Eagle	*Hieraaetus morphnoides*											–	13.4	
Brown Falcon	*Falco berigora*		1.8	2		1.7	1.9	2		3.6		–	22.4	
Australian Hobby	*F. longipennis*					1.7						–	10.4	
Peregrine Falcon	*F. peregrinus*		1.8		1.6							–	20.9	√
Nankeen Kestrel	*F. cenchroides*											–	14.9	
Lewin's Rail	*Rallus pectoralis*											–	1.5	
Baillon's Crake	*Porzana pusilla*										2	–	11.9	
Australian Spotted Crake	*P. fluminea*										2	–	10.4	
Purple Swamphen	*Porphyrio porphyrio*				1.6						98	√	56.7	√
Dusky Moorhen	*Gallinula tenebrosa*										80.4	–	38.8	√
Black-tailed Native-hen	*G. ventralis*											–	1.5	
Eurasian Coot	*Fulica atra*										88.2	–	38.8	√
Painted Button-quail	*Turnix varia*											–	1.5	

(Continued)

APPENDIX 1 (continued)

Species		Survey Sites (%)												
		98 (59)	96 (56)	93 (60)	MW (61)	SS (59)	PS (52)	GL (51)	GW (65)	RC (28)	WC (53)		INC (67)	B
Latham's Snipe	*Gallinago hardwickii*										3.9	–	16.4	
Black-fronted Dotterel	*Elseyornis melanops*										3.9	–	13.4	
Masked Lapwing	*Vanellus miles*				4.9				1.5		7.8	√	64.2	√
Pacific Gull	*Larus pacificus*										2	–	34.3	
Silver Gull	*L. novaehollandiae*											–	16.4	
Common Bronzewing	*Phaps chalcoptera*	8.2	8.9	2	4.9	5.1	5.7	3.9	1.5	17.9		–	58.2	√
Brush Bronzewing	*P. elegans*	14.8	7.1	7.8	3.3	1.7	5.7		1.5	3.6	2	√	52.2	√
Crested Pigeon	*Ocyphaps lophotes*											–	3	
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*											–	10.4	
Galah	*Cacatua roseicapilla*											–	10.4	
Long-billed Corella	*Cacatua tenuirostris*				1.6							–	1.5	
Little Corella	*C. sanguinea*				1.6							–	14.9	
Sulphur-crested Cockatoo	*Cacatua galerita*								1.5		2	–	10.4	
Rainbow Lorikeet	*Trichoglossus haematodus*	4.9	1.8	2	1.6		1.9	5.9	26.2		2	√	53.7	
Musk Lorikeet	*Glossopsitta concinna*	1.6	1.8			1.7			4.6			–	7.5	
Crimson Rosella	*Platycercus elegans*	1.6		2	8.2	1.7	3.8	2			2	–	17.9	
Eastern Rosella	*P. eximius*	19.7	21.4	27.5	19.7	22	3.8	15.7	15.4	10.7	11.8	√	71.6	
Blue-winged Parrot	*Neophema chrysostoma*											–	6	
Pallid Cuckoo	*Cuculus pallidus*	11.5	7.1	3.9	6.6	15.3	11.3	3.9	7.7	3.6	2	–	44.8	
Brush Cuckoo	*Cacomantis variolosus*	1.6	1.8									–	3	
Fan-tailed Cuckoo	*C. flabelliformis*	3.3	5.4	13.7	13.1	6.8	1.9	5.9	32.3	10.7	3.9	–	61.2	
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	3.3	7.1	7.8	6.6	8.5	3.8		7.7	3.6	2	–	47.8	
Shining Bronze-Cuckoo	*C. lucidus*	8.2	1.8	2	6.6	1.7			23.1		3.9	–	41.8	√
Southern Boobook	*Ninox novaeseelandiae*											–	3	
Tawny Frogmouth	*Podargus strigoides*											–	50.7	
Australian Owlet-Nightjar	*Aegotheles cristatus*											–	14.9	
White-throated Needletail	*Hirundapus caudacutus*			2		1.7						–	1.5	
Azure Kingfisher	*Alcedo azurea*											–	1.5	
Laughing Kookaburra	*Dacelo novaeguineae*	1.6						7.8	10.8		5.9	√	46.3	√
Sacred Kingfisher	*Todiramphus sanctus*		1.8	2				2	6.2			–	10.4	
Dollarbird	*Eurystomus orientalis*											–	3	
White-throated Treecreeper	*Cormobates leucophaeus*											–	4.5	
Superb Fairy-wren	*Malurus cyaneus*	32.8	42.9	43.1	19.7	17	22.6	3.9	75.4	50	70.6	√	77.6	√
Southern Emu-wren	*Stipiturus malachurus*	1.6										–	4.5	
Spotted Pardalote	*Pardalotus punctatus*	49.2	55.4	51	19.7	6.8	15.1	13.7	66.2	53.6	7.8	√	86.6	√
Striated Pardalote	*P. striatus*	19.7	17.9	19.6	6.6	1.7	5.7	15.7	40		9.8	–	53.7	
White-browed Scrubwren	*Sericornis frontalis*	78.7	75	88.2	70.5	49.2	22.6		58.5	14.3	9.8	√	77.6	√
Chestnut-rumped Heathwren	*Hylacola pyrrhopygia*	1.6		2								–	0	
Striated Fieldwren	*Calamanthus fuliginosus*				1.6							–	0	
Brown Thornbill	*Acanthiza pusilla*	47.5	80.4	60.8	54.1	37.3	17	13.7	84.6	10.7	27.5	√	74.6	√
Buff-rumped Thornbill	*A. reguloides*											–	0	
Yellow-rumped Thornbill	*A. chrysorrhoa*							3.9			11.8	√	34.3	√
Yellow Thornbill	*A. nana*		1.8					2			2	–	16.4	
Striated Thornbill	*A. lineata*	18	16.1	3.9	6.6	1.7		9.8	23.1			–	52.2	√
Red Wattlebird	*Anthochaera carunculata*	54.1	50	52.9	45.9	50.9	37.7	45.1	49.2	35.7	23.5		82.1	√
Little Wattlebird	*A. chrysoptera*			19.6	11.5		15.1	3.9	9.2	96.4	5.9	√	74.6	
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*											–	4.5	
Bell Miner	*Manorina melanophrys*											–	9	
Noisy Miner	*M. melanocephala*							2				–	7.5	
Yellow-faced Honeyeater	*Lichenostomus chrysops*	42.6	37.5	21.6	9.8	10.2	13.2	2	49.2		3.9	√	53.7	√
White-eared Honeyeater	*L. leucotis*	83.6	66.1	15.7	50.8	18.6	73.6	7.8	47.7	7.1	3.9	√	73.1	√
White-plumed Honeyeater	*L. penicillatus*	3.3	1.8	3.9	13.1	1.7	9.4	3.9	43.1		15.7	√	53.7	√
Brown-headed Honeyeater	*Melithreptus brevirostris*	3.3	3.6	5.9	6.6	3.4			1.5			√	25.4	√
White-naped Honeyeater	*M. lunatus*	50.8	48.2	29.4	29.5	13.6	32.1	3.9	72.3	7.1	5.9	√	65.7	√
Painted Honeyeater	*Grantiella picta*											–	1.5	
New Holland Honeyeater	*Phylidonyris novaehollandiae*	82	82.1	95	95.1	88.1	67.9	5.9	49.2	100	21.6	√	77.6	√
Eastern Spinebill	*Acanthorhynchus tenuirostris*		3.6	3.9					15.4	3.6		–	34.3	

(Continued)

APPENDIX 1 (continued)

Species		Survey Sites (%)										S	INC	B
		98 (59)	96 (56)	93 (60)	MW (61)	SS (59)	PS (52)	GL (51)	GW (65)	RC (28)	WC (53)		(67)	
Scarlet Robin	*Petroica multicolor*											–	11.9	
Flame Robin	*P. phoenicea*				1.6		5.7					–	20.9	
Rose Robin	*P. rosea*								1.5			–	0	
Pink Robin	*P. rodinogaster*											–	4.5	
Eastern Yellow Robin	*Eopsaltria australis*	31.2	33.9	33.3	37.7	10.2	15.1	2	87.7	10.7	11.8	–	76.1	√
Varied Sittella	*Daphoenositta chrysoptera*	1.6		5.9			3.8		1.5		2	–	19.4	√
Crested Shrike-tit	*Falcunculus frontatus*	1.6	1.8	2			1.9		7.7			–	38.8	√
Golden Whistler	*Pachycephala pectoralis*	27.9	7.1	13.7	34.4	18.6	3.8	3.9	44.6		2	–	70.1	√
Rufous Whistler	*P. rufiventris*	19.7	8.9	11.8	9.8	10.2		2	35.4		5.9	–	49.3	√
Grey Shrike-thrush	*Colluricincla harmonica*	49.2	35.7	31.4	41	23.7	20.8	17.7	72.3	7.1	13.7	–	74.6	√
Leaden Flycatcher	*Myiagra rubecula*											–	4.5	
Satin Flycatcher	*M. cyanoleuca*	1.6							6.2			–	13.4	√
Restless Flycatcher	*M. inquieta*								1.5			–	3	
Magpie-lark	*Grallina cyanoleuca*		1.8	7.8	14.8	1.7	1.9	58.8	9.2	7.1	49	√	76.1	√
Rufous Fantail	*Rhipidura rufifrons*	1.6										–	4.5	
Grey Fantail	*R. fuliginosa*	49.2	42.9	43.1	62.3	52.5	22.6	31.4	93.9	7.1	39.2	–	74.6	√
Willie Wagtail	*R. leucophrys*		1.8	5.9	13.1	10.2	5.7	19.6	4.6	25	43.1	√	62.7	√
Black-faced Cuckoo-Shrike	*Coracina novaehollandiae*	3.3	1.8	9.8	6.6	6.8		9.8	21.5	3.6	3.9	–	52.2	√
White-bellied Cuckoo-shrike	*C. papuensis*											–	1.5	
White-winged Triller	*Lalage sueurii*	3.3		2							2	–	13.4	√
Olive-backed Oriole	*Oriolus sagittatus*	1.6										–	4.5	
Masked Woodswallow	*Artamus personatus*	1.6	1.8							7.1		–	4.5	
White-browed Woodswallow	*A. superciliosus*	1.6	1.8									–	6	√
Dusky Woodswallow	*A. cyanopterus*	14.8	12.5	43.1	3.3	18.6	17	2	4.6	3.6	11.8	√	55.2	√
Grey Butcherbird	*Cracticus torquatus*	6.6			3.3			19.6	4.6		5.9	–	65.7	√
Australian Magpie	*Gymnorhina tibicen*		1.8	3.9	6.6	3.4	1.9	52.9	3.1	3.6	31.4	√	59.7	√
Grey Currawong	*Strepera versicolor*		1.8	2								–	6	
Australian Raven	*Corvus coronoides*	16.4	17.9	37.3	6.6	8.5	11.3	7.8	18.5		13.7	–	65.7	
Little Raven	*C. mellori*	24.6	32.1	25.5	27.9	15.3	3.8	54.9	49.2	10.7	15.7	–	80.6	
Richard's Pipit	*Anthus novaeseelandiae*										2	–	25.4	√
Red-browed Finch	*Neochmia temporalis*		8.9	9.8	8.2	3.4	3.8		9.2	3.6	5.9	–	50.7	√
Mistletoebird	*Dicaeum hirundinaceum*	14.8	14.3	21.6	6.6	11.9	3.8	2	16.9	10.7	7.8	–	67.2	√
Welcome Swallow	*Hirundo neoxena*	11.5	3.6	25.5	24.6	30.5	13.2	11.8	1.5	46.4	76.5	√	71.6	√
Tree Martin	*H. nigricans*	8.2	1.8	15.7	1.6	11.9	1.9				7.8	–	22.4	
Fairy Martin	*H. ariel*			2		3.4	1.9				3.9	–	9	
Clamorous Reed-Warbler	*Acrocephalus stentoreus*										39.2	–	25.4	√
Little Grassbird	*Megalurus gramineus*										11.8	–	25.4	
Golden-headed Cisticola	*Cisticola exilis*										9.8	–	28.4	
Silvereye	*Zosterops lateralis*	16.4	16.1	25.5	44.3	22	3.8	2	26.2	7.1	2	√	55.2	√
Bassian Thrush	*Zoothera lunulata*											–	16.4	√