Chapter 3. **BIRD COMMUNITY DYNAMICS**

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## 3.1 **Introduction**

Australian arid zone birds, particularly when compared with native mammals (Dickman *et al.* 1994), are generally perceived to have fared well since European settlement (Burbidge & McKenzie 1989, Morton 1990). However, a number of authors, e.g. Recher & Lim (1990), Reid & Fleming (1992) and Smith & Smith (1994), have voiced concerns regarding the future of these birds. Accurate assessment of changes in the arid zone avifauna is hampered by the meagre historical record and by a lack of detailed information on the present day distribution and abundance of birds (Reid & Fleming 1992). Only three published studies provide estimates of density for arid zone bird communities, namely Brooker *et al.* (1979) in the north-west Nullarbor Plain of Western Australia, Wiens (1991) in chenopod scrubland of north-western New South Wales, and Cody (1994) in mulga scrub across Australia. Only the study of Brooker *et al.* (1979) includes estimates of density for a given site over a number of years and seasons.

Estimates of bird species abundance and composition in the arid zone need to take account of the variable and unpredictable nature of the environment (Stafford Smith & Morton 1990). Droughts occur at irregular intervals (Foley 1957, Reynolds *et al.* 1983), and there are numerous accounts of the devastating effects of drought on the avifauna, e.g. Barnard (1917, 1927), Berney (1906, 1928), MacGillivray (1929), McGilp (1924) and Robertson (1987). Numerical losses of birds in droughts have been attributed to curtailment of breeding as well as mortality (Keast 1959).

In this chapter, I describe the population dynamics of the bird community at the Peery study site in a 3.5 year period that included a severe drought. I present estimates of the density of birds and describe yearly and seasonal patterns in species composition and abundance. I compare the responses of resident, nomadic and migratory species to drought and attempt to relate trends in the avifauna to rainfall. Finally, I compare the avifauna of different habitats within the study area.

## 3.2 **Study site**

The study site is described in detail in Chapter 2. It comprised four broad habitat types: major creeklines with a fringe of eucalypt woodland; more ephemeral drainage lines variously fringed by perennial shrubs and low, mainly non-eucalypt trees; run-off areas with a sparse cover of perennial shrubs or low trees; and run-off areas virtually bereft of trees and shrubs (open plains), but with a variable cover of short-lived grasses, herbs and sub-shrubs including saltbushes *Atriplex* spp. and copperburrs *Sclerolaena* spp.

The study was undertaken between spring 1990 and summer 1994, and can be divided into three periods: pre-drought in 1990, drought in 1991-92, and post-drought in 1993-94 (see Figure 2.2, Chapter 2).

## 3.3 **Methods**

### 3.3.1 **Census**

#### 3.3.1.1 **Pilot study**

Bird census methods are described and reviewed by Ralph & Scott (1980) and Davies (1984b). In a pilot study in early October 1990 I censused a 1200 m transect within, and an 800 m transect outside, creekline habitat, on six occasions over four mornings. I used fixed width transects on account of the linear nature of creekline habitat. Initially, I recorded birds in each 200 m interval of a transect, but variation in vegetation along creeklines was such that a finer division was warranted. Transects were subsequently subdivided into 100 m intervals. Birds were recorded up to 25 m each side of the centre line of the transect. Given the open nature of the vegetation this width is conservative, but suited the narrow strips of creekline habitat. Variability of counts in creekline habitat was such that three counts gave a fair indication of bird density and species composition. However, counts outside creeklines were more variable and I decided to census each transect five times in each survey period.

### 3.3.1.2 **Census method**

Fixed width (50 m) census transects, divided into 100 m intervals, were established to sample the range of habitat variation at the site (Figure 3.1). Greater habitat variation and concentration of birds within creeklines meant that creeklines were sampled more intensively than run-off areas. Transects were placed in all creeklines (nine transects coded CC1, CC2, RC1, RC2, RC3, LC, PW, GG and LS) and in representative areas outside creeklines (six transects coded SS, LS, PH, BB, NH and HP). Thirteen transects were 600 m in length, one 500 m, and one 400 m. The latter two transects were shorter due to the small area of habitat type sampled. Transects within creeklines were separated by breaks of at least 200m. Intervals of 100m were marked in transects with coloured surveyor's tape.

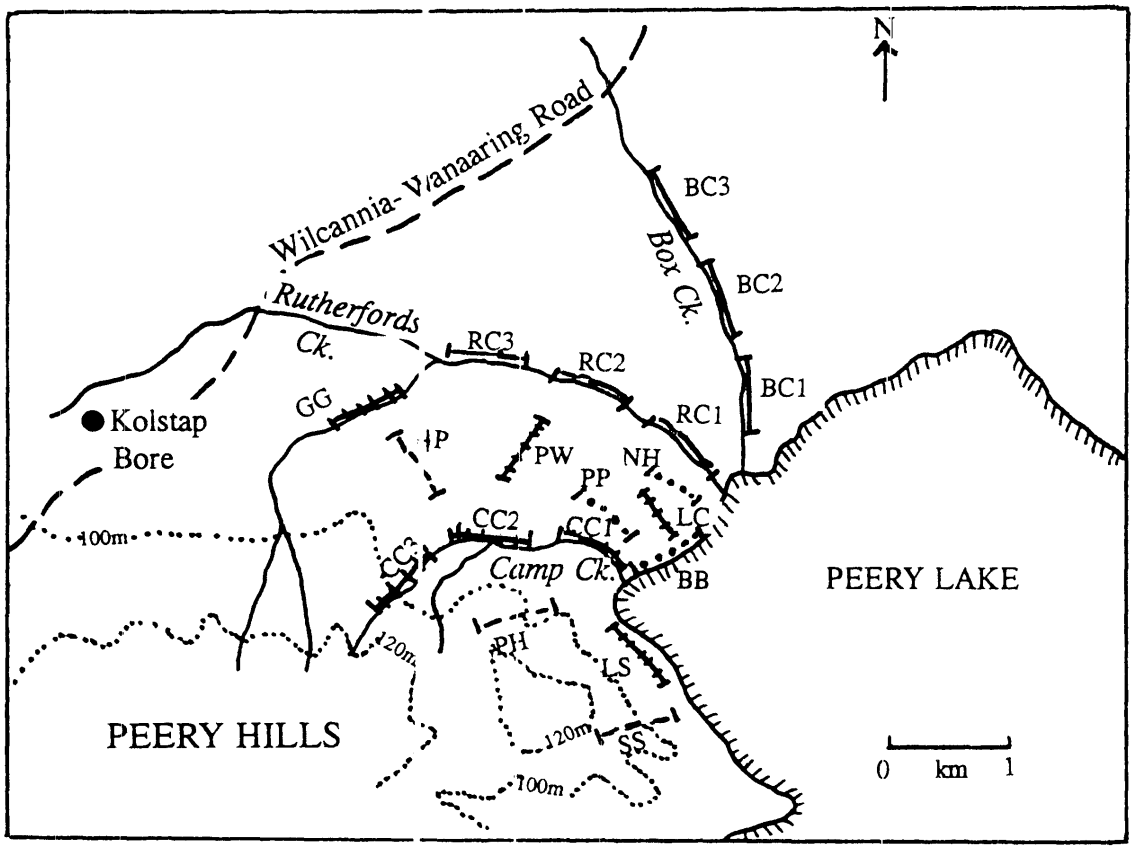
The 15 transects were censused each spring (October) and winter (July) between October 1990 and October 1993, and once in autumn (April 1993) and in summer (January 1994). Dates of field sampling were:

| | |
|---|---|
| Spring 1990 | 10 October - 7 November |
| Winter 1991 | 2 July - 23 July |
| Spring 1991 | 1 October -2 October |
| Winter 1992 | 29 June - 23 July |
| Spring 1992 | 22 September -18 October |
| Autumn 1993 | 9 April - 22 April |
| Winter 1993 | 12 July - 29 July |
| Spring 1993 | 28 September - 20 October |
| Summer 1994 | 18 January - 26 January |

Four additional transects (BC1, BC2, BC3 and CC3) were censused between winter 1991 and summer 1993/94. For the sake of consistency of comparisons between census periods, results from these additional transects have not been included in this chapter.

Spring, winter and autumn censuses were restricted to a four hour period after sunrise. I censused each transect on five different mornings in each census period. The order of counts was varied to spread counts for a given transect throughout the morning and the census period. If uninterrupted by rain, wind, or dust storms, counts could be completed in 15

Figure 3.1. **Sketch map indicating location of census transects within study area.** Transect types are indicated as major creekline ⊢——⊣; minor creekline ⊢⊢⊢⊢ ; run-off with sparse tree/shrub cover ⊢ – – ⊣; run-off, open plains ⊢ • • ⊣.



days. Time available for the summer census was limited. Consequently counts were made in the morning and late afternoon and, on this occasion, Peter Smith assisted with counts. In order to minimise observer variability (Kavanagh & Recher 1983, Kepler & Scott 1980), methods were standardised. The five counts for each transect in the summer survey were divided between Peter Smith and me.

In each census I walked slowly through the transect, deviating from the centre line as necessary to search denser areas of vegetation and hence increase detection of more cryptic species. I took approximately five minutes to search each 100 m transect interval and record birds seen or heard within the interval. Flying birds were not counted unless obviously foraging within the census area. Waterbirds associated with the nearby Peery Lake were occasionally encountered in transects. These were noted, but have not been included in analyses.

### 3.3.1.3 **Analysis of census data**

In each census period the mean density (birds/ha) of birds in each transect was calculated by summing the results of the five counts made and dividing this total by 5, and by the transect area (3 ha in 13 transects, 2.5 and 2 ha in the other two transects). An overall estimate of site density was derived from the mean density of all transects in that census period.

Multivariate methods were used to compare bird species composition over the study area as a whole in different census periods. Multivariate analyses which use untransformed data typically lead to a shallow interpretation in which only the pattern of a few, very common species is represented (Clarke 1993). This was confirmed by exploratory analyses using the untransformed data of this study. Therefore, data (mean density of each species in each census period) were transformed with $\log_0(x+1)$. Transformation meant that less emphasis was placed on bird abundance and more on species composition in comparisons of census periods. Dissimilarity between census periods was calculated using the Bray & Curtis association measure (Belbin 1990). An agglomerative hierarchical clustering strategy, flexible UPGMA (Unweighted Pair Group ArithMetic Averaging) with $\beta = -0.1$, and an ordination procedure, Semi-strong-hybrid Multidimensional Scaling (Belbin 1990), were used to elucidate patterns in

the data.

### 3.3.2 **Classification of birds**

Birds were classified according to their movement patterns as residents, spring-summer or winter migrants, or irregular nomads. Residents were present in all seasons and bred at the site. Spring-summer and winter migrants occurred regularly in the warmer or colder months, respectively, and included breeding and non-breeding species. They were absent at other times of the year, although occasional winter migrants were encountered at the start of spring census periods. Like migrants, nomads were not always present, but the intervals between their visits were irregular and unpredictable.

Over 400 individuals of 33 species were banded and individually marked at the site with colour bands (23 species) or plumage dyes. Individuals of 13 species were re-sighted 12 or more months after banding (Table 3.1). Classification of birds took account of the re-sightings of marked individuals, as well as general site observations over the study period. Classifications made in this study were compared with observations made elsewhere in north-western New South Wales and nearby South Australia including those of Hermes (undated), Denny *et al.* (1977), Schmidt (1973), Wyndham (1978, 1991), Disney (1988), Henle (1989) and Badman (1989).

Birds were also classified according to their use of feeding substrates. Eight feeding groups (ground, ground/aerial, ground/bark, ground/fruit, foliage, flower/foliage, aerial and live vertebrate/carrion) were recognised based on an analysis of foraging behaviour at the site (Chapter 5).

### 3.3.3 **Habitat measurements of census transects**

The ten trees and ten shrubs closest to the central point of each 100 m transect interval (87 intervals) were identified to species and recorded. Distances of the furthest of the ten trees and ten shrubs from the central point were measured. The total density of all trees, all shrubs, and each tree and shrub species within the limits determined by the furthest of the ten trees and

Table 3.1. **Details of species banded at the Peery study site.** The number of individuals resighted more than three months after banding and the maximum time between banding and resighting of an individual of each species are indicated. Most birds were individually marked. A number in parentheses following the number banded indicates the number of birds not individually marked for each species.

| Species | Number banded | First banding date | Number resighted >3mths | Maximum resighting time | Maximum distance between resightings (m) |
|---|---|---|---|---|---|
| Peaceful Dove | 2 | Oct '91 | 0 | 14 days | 550 |
| Diamond Dove | 5 | Apr '93 | 0 | 5 days | 100 |
| Crested Pigeon | 1 | Oct '91 | 1 | 21 mths | 1450 |
| Mallee Ringneck | 4 | Oct '92 | 0 | 0 | |
| Mulga Parrot | 1 | Jul '93 | 0 | 0 | |
| Sacred Kingfisher | 2 | Oct '92 | 0 | 5 days | <100 |
| Rainbow Bee-eater | 6 (6) | Oct '92 | 0 | 0 | |
| Tree Martin | 6 | Oct '92 | 2 | 12 mths | 250 |
| White-winged Triller | 1 | Oct '92 | 0 | 0 | |
| Red-capped Robin | 2 | Jul '92 | 0 | 0 | |
| Grey Shrike-thrush | 4 | Oct '91 | 3 | 27 mths | 2500 |
| Willie Wagtail | 5 | Oct '91 | 4 | 15 mths | 3700 |
| Grey Fantail | 1 | Jul '92 | 1 | 12 mths | 200 |
| Chestnut-crowned Babbler | 7 | Oct '91 | 0 | 6 days | 400 |
| Rufous Songlark | 4 (2 | Jul '93 | 0 | 0 | |
| White-winged Fairy-wren | 5 | Oct '91 | 3 | 24 mths | 950 |
| Variegated Fairy-wren | 9 | Oct '91 | 6 | 18 mths | 400 |
| Chestnut-rumped Thornbill | 6 | Oct '91 | 4 | 9 mths | 1000 |
| Yellow-rumped Thornbill | 5 | Oct '91 | 1 | 6 mths | 200 |
| Southern Whiteface | 8 | Oct '91 | 5 | 12 mths | 400 |
| Brown Treecreeper | 10 | Oct '91 | 6 | 27 mths | 1000 |
| Yellow-throated Miner | 16 | Oct '91 | 5 | 9 mths | 1700 |
| Spiny-cheeked Honeyeater | 26 | Jul '92 | 8 | 18 mths | 2600 |
| White-plumed Honeyeater | 209 | Oct '91 | 116 | 27 mths | 4700 |
| Singing Honeyeater | 9 (4 | Jul '92 | 2 | 15 mths | 500 |
| Pied Honeyeater | 2 | Jul '93 | 0 | 0 | |
| White-fronted Honeyeater | 4 (4) | Jul '92 | 0 | 0 | |
| Crimson Chat | 10 (1 ) | Jul '93 | 0 | 0 | |
| Striated Pardalote | 1 | Jul '92 | 0 | 0 | |
| Zebra Finch | 13 | Oct '92 | 1 | 3 mths | 100 |
| Apostlebird | 14 | Oct '91 | 4 | 24 mths | 1100 |
| Black-faced Woodswallow | 3 | Jul '93 | 0 | 0 | |
| Australian Magpie | 2 | Apr '93 | 1 | 3 mths | 1150 |

shrubs recorded, were calculated for each interval. The maximum height of vegetation in each 100m interval was measured with a clinometer. The width of the linear strip of riparian habitat at the central point of each creekline transect interval was measured with a tape measure. Mean values of tree and shrub density, vegetation height and width of riparian habitat for each transect were calculated from the values of their 100 m intervals.

### 3.3.4 **Rainfall**

Rainfall at the study site is presumed to be intermediate between that recorded for Wilcannia and White Cliffs (Figure 2.2, Chapter 2). Monthly records for Wilcannia and White Cliffs for the study period and preceding 12 months are highly correlated ($r = 0.780$, d.f. = 50, $p < .001$). I therefore calculated the mean of the two sets of rainfall data to provide the best available indication of rainfall at the study site.

Census results were compared with rainfall in the previous month and with the cumulative totals of the previous two to 12 months to allow for a time lag in response to rainfall. The overall density of birds and the numbers of species of all birds, resident birds, spring-summer migrants, winter migrants and nomads recorded in each census period, were related to the twelve sets of rainfall data using a correlation analysis.

## 3.4 **RESULTS**

### 3.4.1 **The avifauna**

Ninety-seven landbird species were recorded at the study site over the survey period (Appendix 3.1). Only two were introduced species. A single vagrant Feral Pigeon was seen in spring 1991. Common Starlings nested at the site in spring 1990 and occasional individuals were noted in spring 1991 and summer 1993/94.

The 95 native birds comprised members of 32 families (Simpson & Day 1993). Well-represented families included the cockatoos and parrots (Psittacidae, 9 species), honeyeaters (Meliphagidae, 9 species), woodswallows and allies (Artamidae, 7 species),

pardalotes, thornbills and allies (Pardalotidae, 7 species) and pigeons and doves (Columbidae, 5 species). Birds were derived from four biogeographic elements (Schodde 1994): Multifaunal (widespread birds not clearly associated with a particular biogeographic region), Eyrean (birds associated with the Australian arid zone), Bassian (birds associated with mesic southern Australia) and Torresian (birds associated with mesic northern Australia). The study area is within the Eyrean zone and the Eyrean element was most numerous (43% of native landbirds). The Multifaunal element was also well represented (39%) but, not surprisingly, lesser numbers of species of Bassian (9%) and Torresian (8%) origin occurred.

Eighty-one landbird species were recorded in censuses. These were classified as 42 residents, 28 nomads, 6 spring-summer migrants and 5 winter migrants (Appendix 3.1). They comprised 29 ground feeders, 12 foliage feeders, 11 aerial feeders, 11 flower/foliage feeders, 9 live vertebrate/carrion feeders, 5 ground/fruit feeders, 2 ground/aerial feeders and 2 ground/bark feeders. The 16 species not recorded in censuses included wide-ranging birds of prey, nocturnal birds and species present only in very low numbers.

### 3.4.2 **Habitat measurements of census transects**

Maximum vegetation height and densities of trees and shrubs occurred in census transects in major creeklines. The height and density of transect vegetation was progressively reduced in more ephemeral drainage lines and in run-off areas with sparse perennial trees and shrubs, and reached a minimum on the open plains. Table 3.2 summarises details of the vegetation of the transects in each major habitat type.

### 3.4.3 **Comparison of the avifauna of the nine census periods**

The species composition and abundance of the avifauna varied greatly between census periods. The UPGMA analysis indicated major differences between the pre-drought (1990), drought (1991-92) and post-drought (1993-94) periods of the study (Figure 3.2). The greatest change in birds coincided with the breaking of the drought, between Spring 1992 and Autumn 1993. The ordination of results (Figure 3.3) revealed a seasonal, as well as an annual, component of

Table 3.2. **Summary of vegetation measures made in transects in the four major habitat types.** Values in table are mean ± standard error. Trees are ≥4m in height and shrubs >0.5m but <4m.

| TRANSECT HABITAT TYPE | NAMES | TREE DENSITY (trees/ha) | MAIN TREE SPECIES | SHRUB DENSITY (shrubs/ha) | MAIN SHRUB SPECIES | VEG. HT. (m) | VEG. WIDTH (CREEKLINE) (m) |
|---|---|---|---|---|---|---|---|
| **1.RUN-ON :** | | | | | | | |
| **i. MAJOR CREEKLINE** | RC1, RC2, RC3 | 141 ± 19 | *Eucalyptus camaldulensis, E. largiflorens, Acacia stenophylla* | 1991 ± 938 | *Myoporum montanum, A. stenophylla* | 12.6 ± 0.7 | 97.5 ± 8.9 |
| **ii. MINOR CREEKLINE** | PW, GG, CC1, CC2, LC,LS | 84 ± 20 | *Acalaya hemiglauca, Acacia victoriae, Grevillea striata, E. largiflorens, Alectryon oleifolius* | 685 ± 163 | *Myoporum montanum, A. stenophylla, A. victoriae, A. tetragonophylla, Senna artemisioides* | 8.3 ± 0.5 | 37.3 ± 6.8 |
| **2. RUN-OFF:** | | | | | | | |
| **i. SPARSE TREE SHRUB COVER** | HP, PH, SS | 42 ± 13 | *Acacia aneura* | 359 ± 139 | *S. artemisioides, M. montanum, A. aneura* | 5.8 ± 0.6 | |
| **ii. OPEN PLAIN** | NH, PP, BB | 1 ± 1 | *A. hemiglauca, A. stenophylla, E. largiflorens* | 170 ± 75 | *Muehlenbeckia florulenta, Eragrostis australasica, A. stenophylla* | 2.9 ± 0.5 | |

Figure 3.2. **Classification of census periods based on similarities in species composition and abundance of the avifauna**. The dendrogram illustrates the history of the UPGMA classification.

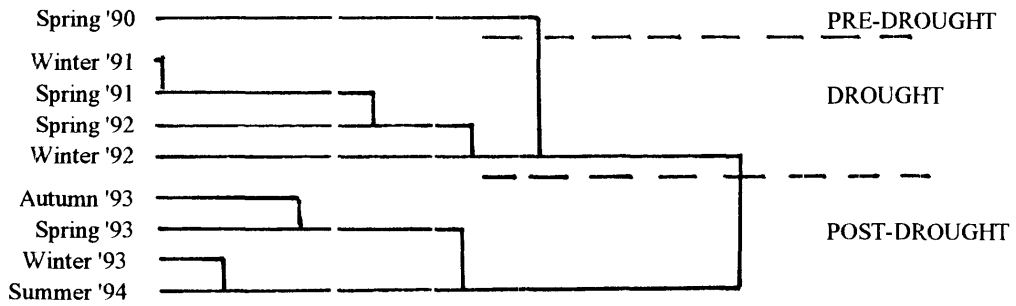
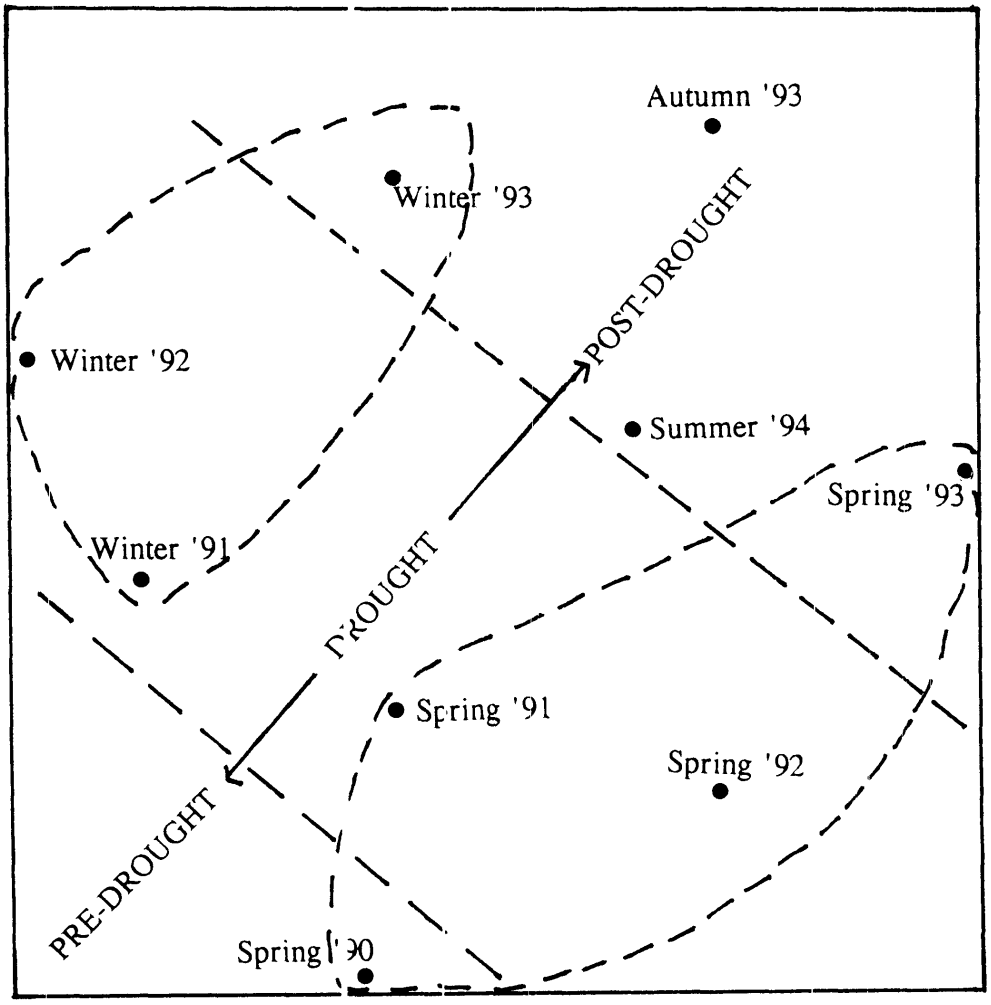


Figure 3.3. **Ordination of census periods based on abundance and species composition of the avifauna.** Axes are scaled dependently.



variation in the avifauna with spring censuses clearly separating from winter censuses.

### 3.4.4 **Temporal patterns in abundance**

Overall numbers of birds at the site declined quickly with the onset of drought, dropping from a mean transect density of 19.5 birds/ha in spring 1990 to 9.6 birds/ha the following winter (Figure 3.4). Bird numbers remained low throughout the drought and reached a minimum of 8.7 birds/ha in spring 1992. Following the breaking of the drought, bird numbers were high in autumn and spring 1993, but low in winter and summer. Variation between transects in terms of bird densities was greatest in spring 1990, before the drought, and in autumn and spring 1993, after the drought.

In spring 1990, the avifauna was dominated by resident birds, with the Tree Martin and White-plumed Honeyeater easily the most numerous species. The fall in numbers between spring 1990 and winter 1991 was largely attributable to a decline in numbers of residents (Figure 3.5). In contrast, the post-drought increase in numbers resulted mainly from an influx of nomadic species, such as Zebra Finch, Budgerigar, Crimson Chat, Diamond Dove and Rufous Songlark. Numbers of spring-summer and winter migrants were low throughout the study.

Before the drought (spring 1990), aerial feeders, flower/foliage feeders and ground feeders dominated the avifauna (Figure 3.6). Numbers of flower/foliage feeders remained fairly constant throughout the study, while numbers of aerial and ground feeders declined when drought set in. Numbers of ground feeders peaked in autumn 1993 after the drought and ground/fruit feeders were most numerous in the autumn and spring after the drought.

### 3.4.5 **Temporal patterns in species richness**

The number of species recorded in transects ranged from 51 in Spring 1990 to 37 in Winter 1991 (Figure 3.7). Fluctuations in numbers of species were less pronounced than density changes. Differences in numbers of species recorded in winter and spring of the same year were not consistent. Residents accounted for from 63% (autumn 1993) to 81% (winter 1991) of all species in each census. The number of nomadic species was lowest in 1991, the first year of the drought, and highest in 1992, the year after the drought.

Figure 3.4 **Mean site density of avifauna in each census period.** In each season 15 transects were censused. Bars indicate standard error of mean.

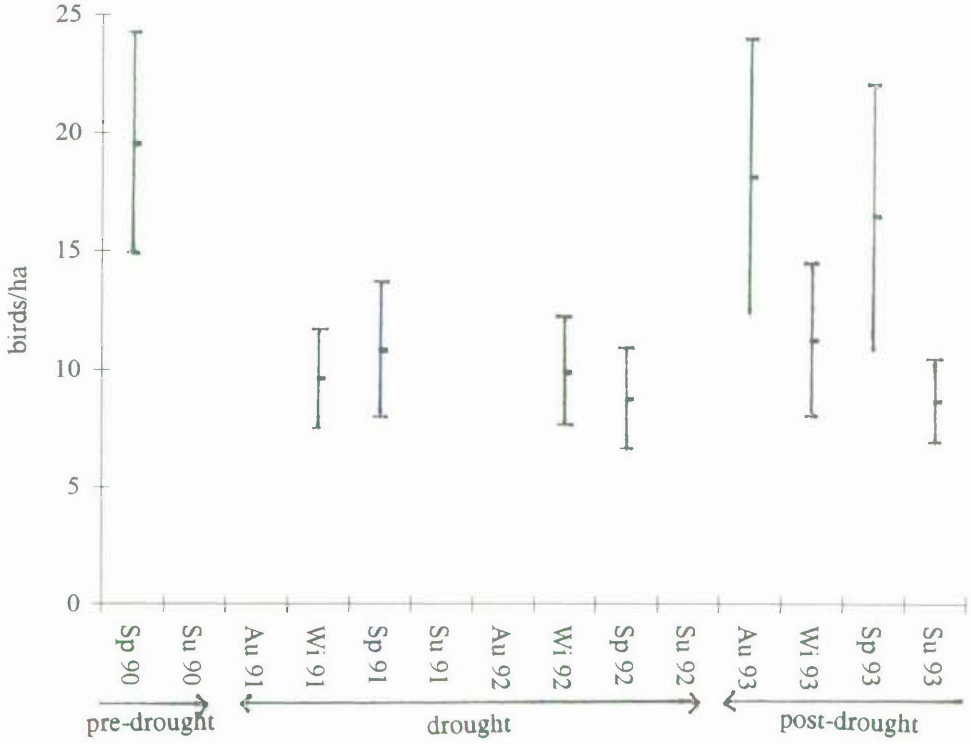


Figure 3.5. **Composition of avifauna in census transects**. The abundance of Tree Martins — — — and White-plumed Honeyeaters • • • • is indicated for each census period.

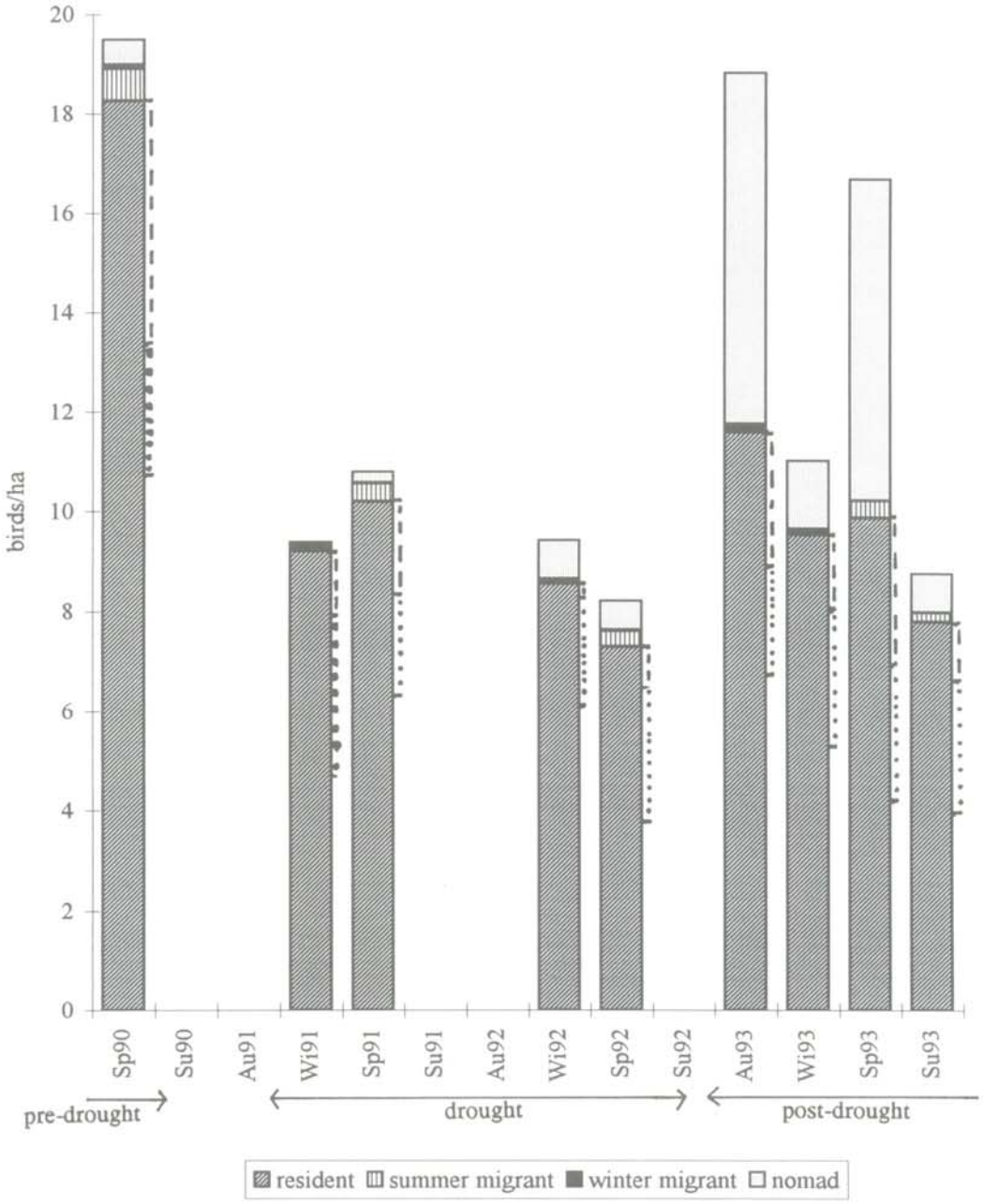


Figure 3.6. **Relative abundance of feeding groups in census transects in each census period.**

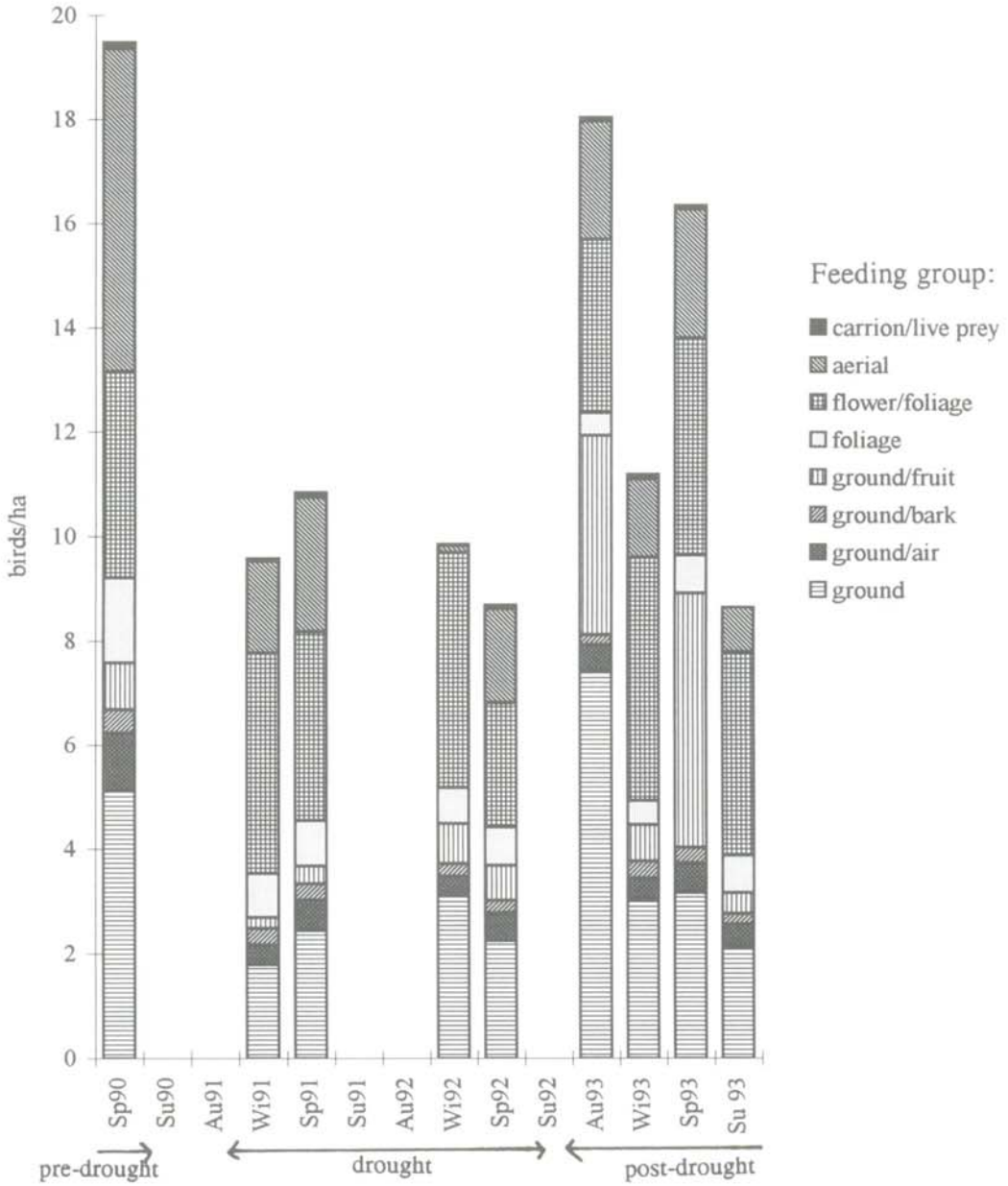
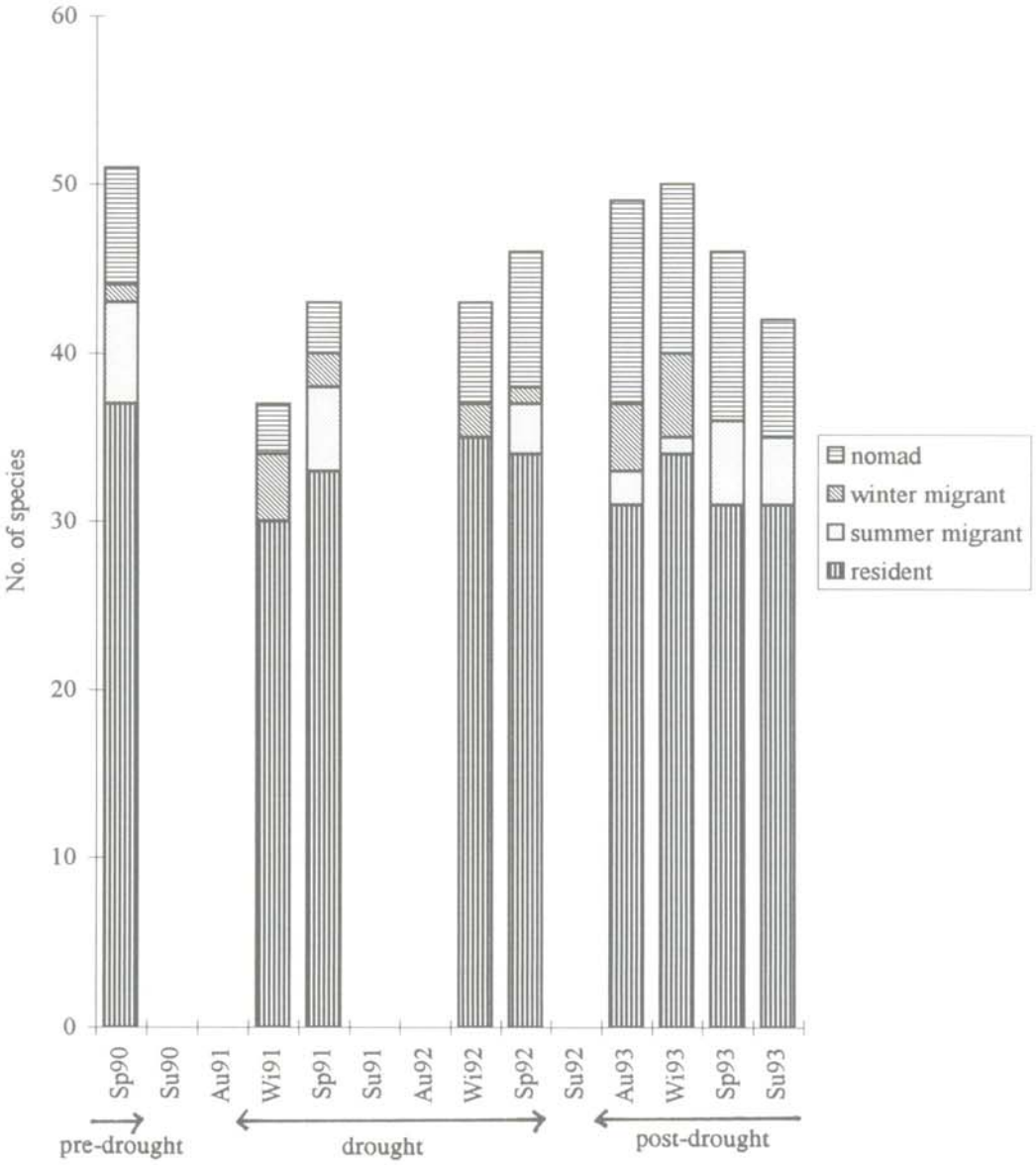


Figure 3.7. **Numbers of species of each status group recorded in census transects in each census period.**



There were only modest changes in species richness of all foraging groups through the study period (Figure 3.8). The ground feeding group was most rich in species with ground feeders accounting for at least 35% (spring 1992) and up to 45% (summer 1993/94) of species in transects.

### 3.4.6 **Bird/rainfall patterns**

Total bird density and the densities of residents, spring-summer migrants and winter migrants in each census period were not correlated with total rainfall in any of the prior one to 12 month periods (all p values $> 0.05$). However, the density of nomads was significantly correlated with rainfall in the previous three, four, five and 10, 11 and 12 month periods ($r = 0.698$, 0.703, 0.760, 0.776, 0.793, 0.747 respectively, d.f. =7, $p < 0.05$). Similarly, the total number of species and numbers of resident, summer migrant and winter migrant species were not correlated with rainfall. The number of nomadic species recorded was significantly correlated with rainfall in the previous six to 12 month periods ($r = 0.721$, 0.782, 0.792, 0.854, 0.867, 0.852, 0.797 respectively, d.f. =7, $p < 0.05$).

### 3.4.7 **Comparison of the avifauna of the four main habitat types**

Mean bird density in individual transects over the study period ranged from 1.0 ($\pm$ s.e. 0.2) bird/ha to 35.5 ($\pm$ s.e. 9.3) birds/ha (Figure 3.9). There were significant differences between habitat types (ANOVA, $F_{14,120} = 7.09$, $p < 0.001$). Densities were higher in creekline habitats than in run-off areas (ANOVA, $F_{1,120} = 35.35$, $p < 0.001$) and densities in major creeklines were higher than in minor creeklines (ANOVA, $F_{1,120} = 52.64$, $p < 0.001$). The lowest densities were recorded in run-off areas which lacked a cover of trees or shrubs, that is, the open plains. The bird densities recorded in transects in major creeklines varied most over the study period. Some variability in individual transects was related to influxes of particular species, including Zebra Finches, Budgerigars, Tree Martins and honeyeaters. Bird densities in transects closest to Peery Lake (BB, SS and LS) were relatively high in spring 1990 when the Lake was full.

Figure 3.8. **Relative species composition of census transects in terms of feeding groups in each census period.**

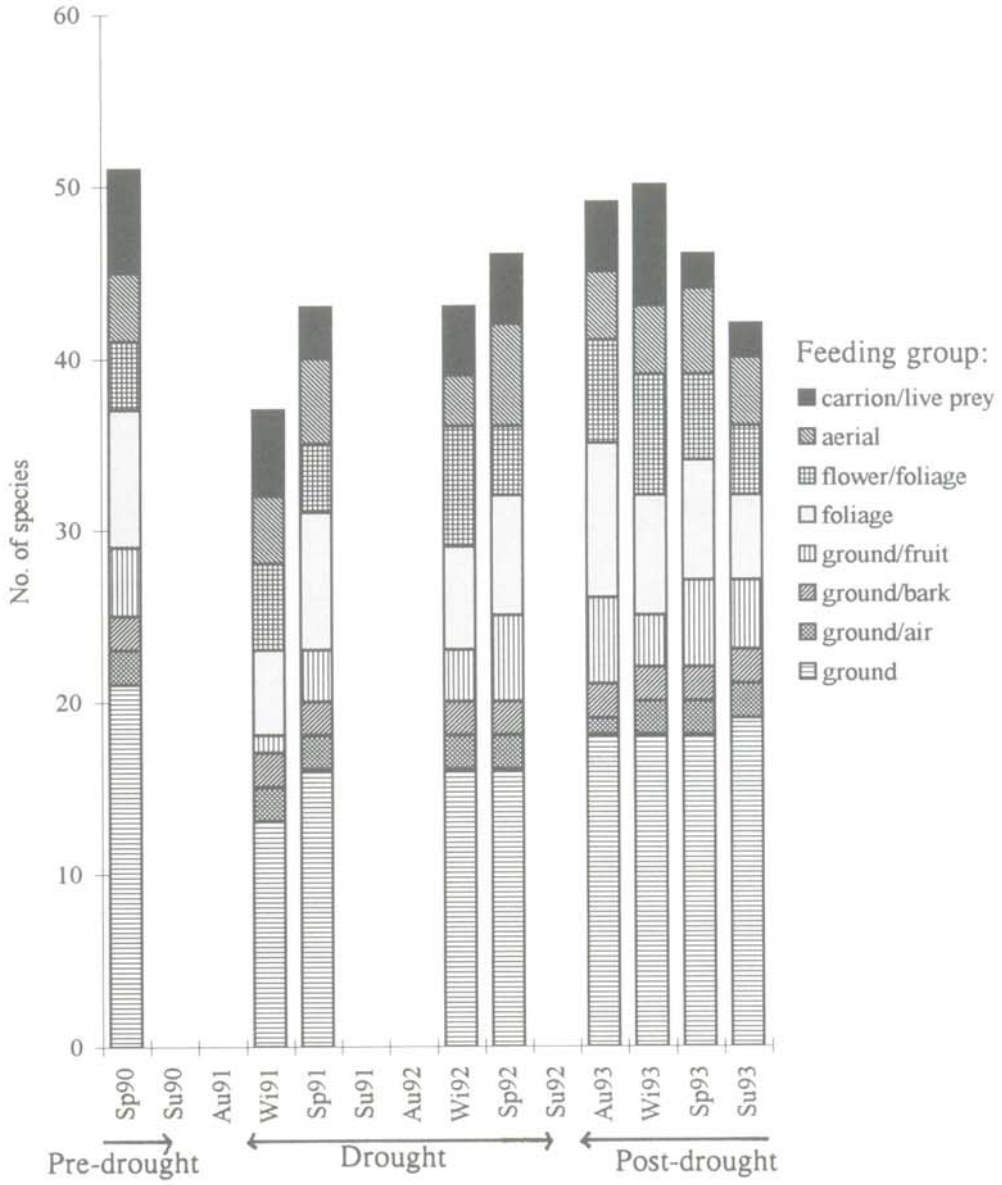
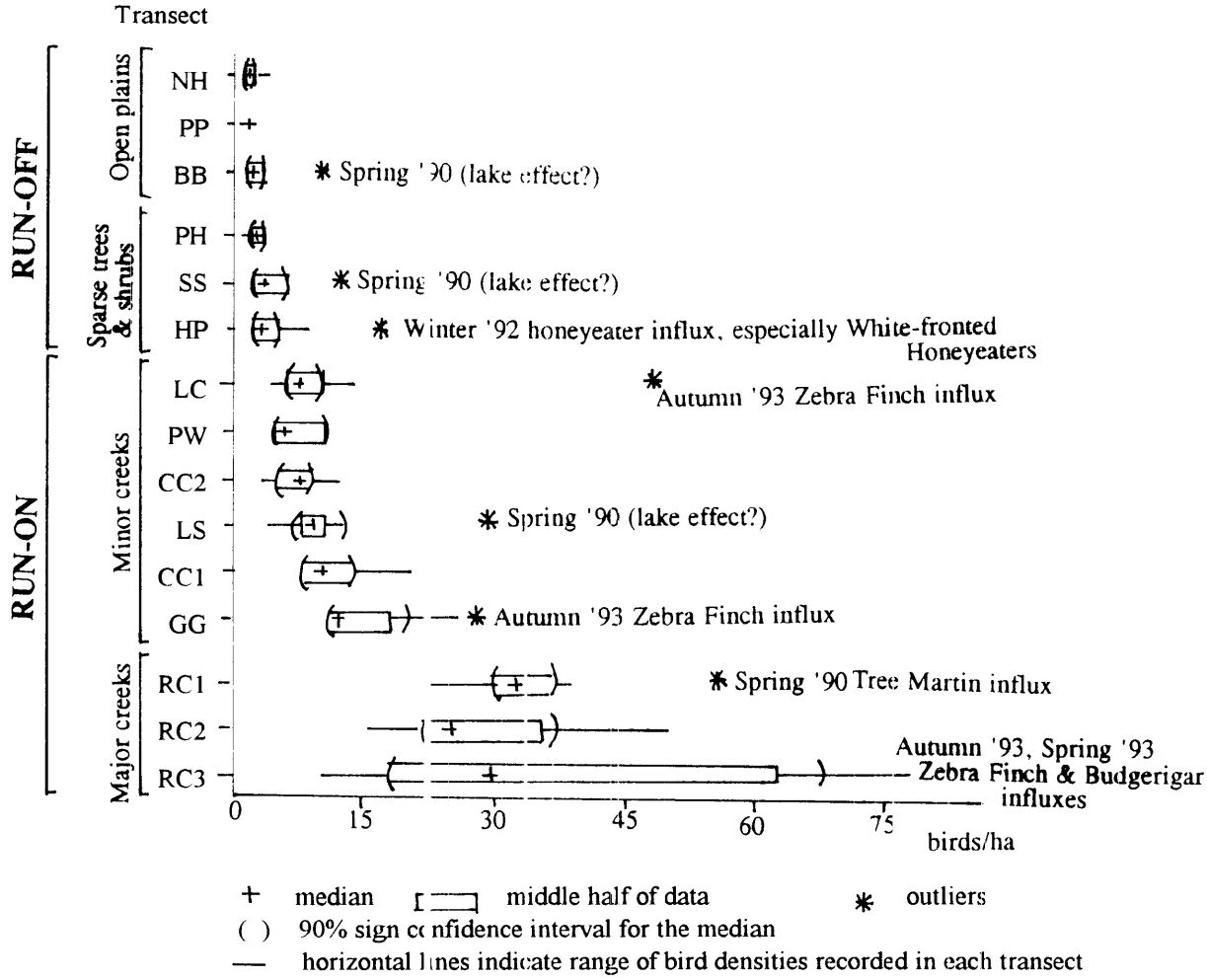


Figure 3.9. **Spatial patterns in bird density in census transects over study period.** Transects whose sign confidence intervals do not overlap are significantly different at roughly the 5% level (Minitab 1989).



Species richness also differed significantly between habitat types (ANOVA, $F_{4,120} = 22.14$, $p < 0.001$) (Figure 3.10). Mean species richness of individual transects over the study period ranged from 3.3 (±s.e. 0.7) to 20.1 (±s.e. 1.1) species/transect. Species richness was greater in creeklines than in run-off areas (ANOVA, $F_{1,120} = 184.16$, $p < 0.001$). Least rich were transects of the open plains followed by transects of run-off areas with some shrub or low tree cover. Unlike density, the difference between major and some of the minor creeklines (GG, CC1 and LS) was not significant (ANOVA, $F_{1,120} = 3.69$, $p > 0.05$).

### 3.4.8 **Temporal patterns in numbers of individual species**

The mean density of each species in each census period is given in Appendix 3.1, together with the number of census transects (maximum 15) in which the species was recorded. The magnitude and direction of population fluctuations of individual species were not consistent. Of the 22 most common residents (densities greater than 1 bird/ha) in spring 1990, the densities of all but the White-plumed Honeyeater and Grey Shrike-thrush were lower in spring 1993. Numbers of White-plumed Honeyeater, second only to the Tree Martin in total abundance, increased by over 50% between spring 1990 and spring 1993, but the Grey-shrike Thrush increased only slightly. In the same period, numbers of Tree Martins declined by a factor of about three. The small, similar-sized Chestnut-rumped and Yellow-rumped Thornbills and Variegated and White-winged Fairy-wrens were present in roughly equivalent numbers in spring 1990. Population declines were greatest in the Chestnut-rumped and Yellow-rumped Thornbills, whose densities declined by factors of 11 and eight respectively. In contrast, densities of the Variegated and White-winged Fairy-wrens were only about halved in spring 1993.

Total numbers of nomadic birds peaked after the drought in autumn and spring 1993 (Figure 3.11). The autumn peak was dominated by Zebra Finches and to a lesser extent Budgerigars. In spring 1993, Budgerigars were over nine times as numerous as Zebra Finches. Numbers of other nomads peaked at other times. Numbers of White-fronted Honeyeaters and White-browed Woodswallows peaked during the drought, the White-fronted Honeyeaters in winter 1992 and the White-browed Woodswallows in spring 1992. The peaks in numbers of

Figure 3.10. **Spatial patterns in species richness in census transects over study period.** Transects whose sign confidence intervals do not overlap are significantly different at roughly the 5% level (Minitab 1989).

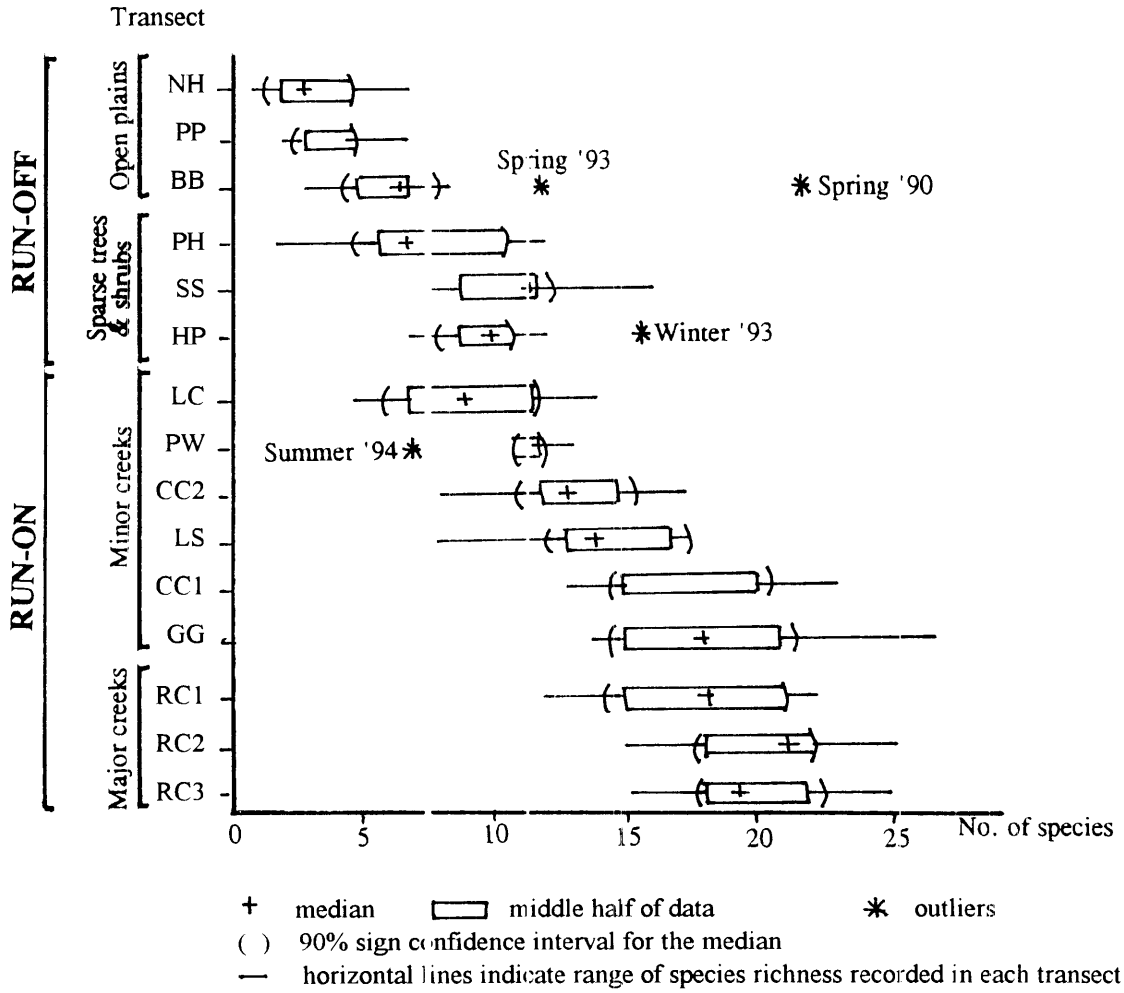
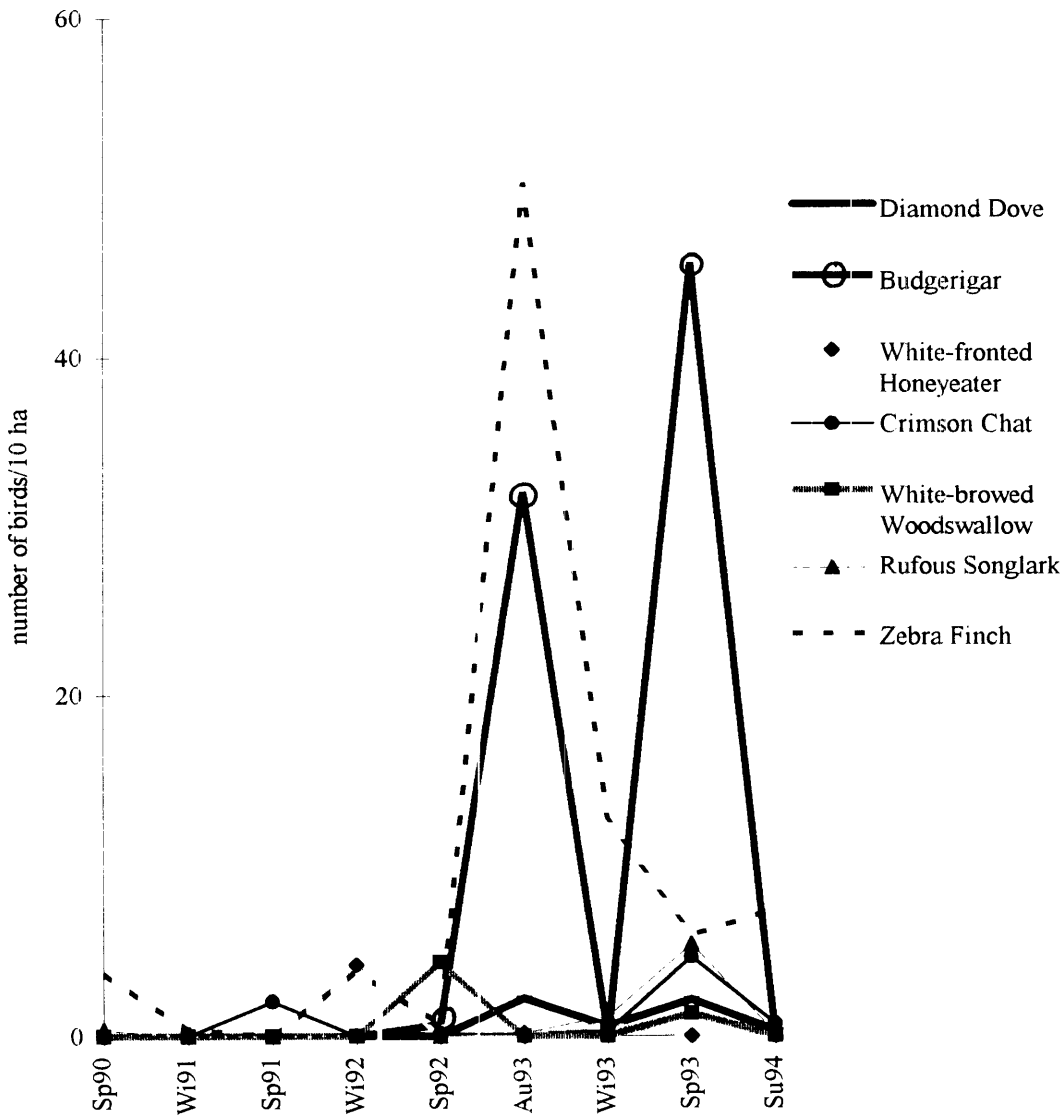


Figure 3.11. **Fluctuations in numbers of selected nomads over study period.**



these species were, however, much lower than those recorded for the Zebra Finch and Budgerigar.

## 3.5 **DISCUSSION**

In this study, 52% of all species recorded in censuses were classified as residents, 35% as nomads and the remainder as regular migrants. A predominance of resident species has also been recorded in land bird communities elsewhere in the arid zone (Henle 1989, Brooker *et al.* 1979, Wyndham 1978, Pianka & Pianka 1970, Hermes undated), as well as in most Australian habitats. The proportion of nomads at Peery is slightly higher than the figure of 26% estimated by Keast (1959) for the entire Australian avifauna. Though many birds in arid Australia are nomadic, the avifauna is certainly not dominated by nomads.

The status of species was determined from movement patterns observed at the Peery site. My classifications of a number of species differed from those made in other parts of the species' range within, or at the margin of, the arid zone. The Grey Butcherbird, for instance, was a non-breeding winter visitor at Peery, but a common resident at Cobar (Schmidt 1978). In the Milparinka district and Cooper Creek basin the White-breasted Woodswallow was a nomad and the Mallee Ringneck and Spiny-cheeked Honeyeater were winter visitors (Wyndham 1978). At Peery, the White-breasted Woodswallow was a regular summer breeding migrant and the Mallee Ringneck and Spiny-cheeked Honeyeater were residents. Wyndham (1978) found the Budgerigar, Zebra Finch, Rufous Songlark, Stubble Quail and Little Button-quail to be resident, but at Peery they occurred nomadically.

The varied classifications may reflect differences in habitat quality for particular species in different localities and times. Peery, in comparison with Cobar, might provide only marginal habitat for the Grey Butcherbird and these winter visitors at Peery may be part of a post-breeding dispersal from more favourable areas. Observations made when conditions are consistently good, as when Wyndham's (1978) observations were made, are likely to suggest that nomadic species are resident, since there may be no impetus for them to quit an area. Further, some species may be partly sedentary and partly nomadic within an area. At Peery the Tree Martin, for example, was classified as a resident. It was present in all census periods and

nested each spring. One pair nested in the same hollow in consecutive springs (Chapter 6). However, huge fluctuations in Tree Martin numbers (some sixty fold overall) suggested influxes of nomadic birds into and out of the area. A similar mix of nomadic and sedentary individuals has also been indicated in populations of Striated Pardalotes (Woinarski 1988). It is also possible that some species may be present all year and apparently resident, though all individuals may be moving in and out of the area.

In this local study, the Black Honeyeater, Budgerigar and White-browed Woodswallow appeared to be classic nomads. They occurred irregularly and sometimes in large numbers. However, large-scale reviews (Ford 1978, Wyndham 1982, Wood 1994) of the movements of these birds have shown that although they vary greatly in abundance and distribution from year to year, there is nevertheless a regular north-south pattern to their movements. Ford (1989) concluded that the movements of many species fall between the extremes of true migration and nomadism.

Changes in the avifauna over the study period could be related to both drought and seasonal (winter-spring) effects. The onset of drought was accompanied by a marked decline in numbers of resident birds, especially in the transects closest to Peery Lake. The proximity of fresh water in the Lake, which was full before the drought and receded during the drought, probably contributed to the particularly high pre-drought densities in transects near the Lake margin. Residents were slow to recover when conditions improved after the drought and the Lake re-filled. In this variable environment droughts are an "ecological crunch" (Wiens 1977, 1989), and there is a time lag between the response of individuals or populations to changes in resource levels. Droughts may thus keep numbers below carrying capacity in favourable times.

Numbers of all feeding groups apart from flower/foliage feeders declined in the drought. Flower/foliage feeders included the nomadic White-fronted Honeyeater and resident White-plumed, Spiny-cheeked and Singing Honeyeaters, and Yellow-throated Miner. Perennial plant species, which flowered regularly in the study period despite the drought, were the chief source of flowers for this group. Virtually all feeding observations of the White-fronted Honeyeater involved the perennial, winter-flowering shrub, Harlequin Eremophila *Eremophila duttonii* (Chapter 5). Numbers of White-fronted Honeyeaters peaked in winter 1992, at the height of the drought. They were absent from the site in winter 1991 and occurred in only very

low numbers in winter 1993, despite there being no obvious differences in the abundance of Harlequin Eremophila flowers in the three winter periods. Resident flower/foliage feeders used a broad range of feeding substrates. Eucalypts in major creeklines, which supplied carbohydrates in the form of lerps and galls, as well as insects, were their main site for foliage gleaning (Chapter 5). These eucalypts tap supplies of subterranean water and may, to some extent, be buffered from the effects of drought. The flower/foliage feeders probably suffered less than other residents in the drought due to the relative stability of their food supply. Measures of flowering intensities and invertebrate abundances, availabilities and depletion rates in major creeklines, in both drought and non-drought periods, are needed to confirm this.

The relative stability of the food supply of some resident species in a period of short-term drought may, in part, explain why numbers of residents were not correlated with rainfall in the previous 12 months. Additionally, residents were slow to respond to improved conditions. Given their depleted numbers and their generally regular, rather than opportunistic, breeding patterns (Chapter 6), they may have been incapable of rapid population increases. Rates of population change will also be affected by factors not directly attributable to rainfall, for example, predation pressure. Predators of birds at the site included feral cats, foxes, snakes, goannas and avian predators including the Collared Sparrowhawk and Australian Hobby. The lack of correlation between rainfall and numbers of migratory birds was not surprising, considering the regularity of their movements and the additional influences on their populations of site conditions outside the study area.

In contrast to residents and migrants, the correlations found between numbers of nomads and preceding rainfall emphasised the greater mobility and flexibility of nomads. Nomads are able to evade harsh drought conditions and to take advantage rapidly of improved conditions. The significant correlations between nomad numbers and rainfall in the preceding three to five and 10-12 month periods related to two peaks in their numbers after the heavy rains in summer 1992-93, one in autumn and one in spring 1993. The peaks were of similar size, but differed in species composition. In autumn, nomads consisted largely of small granivorous Zebra Finches, Budgerigars and Diamond Doves. In spring, Budgerigars were more common and numbers of Zebra Finches and Diamond Dove were reduced. The insectivorous Crimson Chat and Rufous Songlark were more common in spring than autumn.

In contrast to these general trends in nomad numbers, populations of some nomads peaked during the drought. The White-fronted Honeyeater, as noted previously, was most common in winter 1992. Numbers of White-browed Woodswallow peaked in spring 1992, when it also nested and fledged young (Chapter 6). Observations of White-browed Woodswallows have suggested that, in times of inland drought, they are nomadic invaders of coastal areas in which conditions are relatively more suitable (Recher & Schulz 1985, Wood 1994). On this occasion, an isolated thunderstorm at Peery several weeks before the spring 1992 census may have induced them to settle and breed at the site, despite the widespread and severe drought. At Peery, the White-browed Woodswallow fed almost exclusively on aerial invertebrates (Chapter 5), but without measures of abundance of aerial invertebrates it is not possible to say if White-browed Woodswallows were attracted by an increased availability of food. Numbers of all nomadic species, including the White-browed Woodswallow, must, however, be determined to some extent by the relative availability of food outside compared with inside the study area.

Overall patterns discerned in this study are indicative of the generally deleterious effects of drought on birds. The varied responses of different species suggest that drought has a differential effect on resources. Different species, each with unique habitat requirements, respond accordingly. Studies in arid areas outside Australia have shown that species vary greatly in abundance from year to year and place to place, apparently independently of each other (Wiens & Rotenberry 1980, 1981, Rosenberg *et al.* 1982, Rice *et al.* 1983a,b).

The spatial variability found in the avifauna of the study site reflects the spatial heterogeneity of arid areas at a local level. Such heterogeneity needs to be considered when planning surveys. In the study area, the relatively mesic creekline habitats supported more birds and more species than habitats of run-off areas. The importance of creekline habitats to birds of arid areas is supported by the studies of Pianka & Pianka (1970), Wyndham (1978), Brooker *et al.* (1979), Badman (1989) and Henle (1989). Creekline habitats are structurally more complex and more productive than run-off habitats. They provide diverse feeding opportunities for birds and are a source of nesting, roosting and watering sites. They also offer protection from predators for birds which feed in and outside of, creeklines. Thirteen species were only recorded in creekline transects. Species were not evenly spread throughout creeklines and the distribution of birds within creeklines is investigated in Chapter 4. Only one

species, the White-fronted Chat, was recorded only in run-off transects. The avifauna of run-off areas, however, was not merely a depauperate imitation of the avifauna of creekline habitats. A number of species, including the Southern Whiteface, Red-capped Robin, Richard's Pipit and Crimson Chat, were largely confined to run-off areas and only ventured into the upper reaches of creeks which graded into run-off habitat.

Birds were censused to provide an index rather than an absolute measure of abundance. Birds unseen when counting until flushed are indicative of the difficulties of detecting silent, stationary birds in thick foliage or cryptically coloured birds in herbage on the open plains. Census methods were standardised to achieve comparable indices of density for each census. Comparisons assume that birds were equally detectable in all transects and periods. Comparisons of results of this study with results of other studies using different counting methods need to be made with great caution - density estimates derived using different methods and observers are not necessarily comparable. Further, the temporal and spatial heterogeneity of the arid zone avifauna, as revealed in this study, needs to be considered. Within the arid zone, Cody (1994), in mulga scrub between late winter and early summer, estimated that the density of birds ranged from 7.0-17.0 birds/ha, while Wiens (1991), in chenopod scrubland in summer, estimated 0.9-2.1 birds/ha. The longer term study of Brooker *et al* (1979) on the Nullarbor Plain noted temporal variation within habitats. They recorded their lowest (0.3 birds/ha) and highest (5.6 birds/ha) densities in open myall *Acacia sowdenii* woodland. These figures are towards the lower end of densities recorded at Peery. In more mesic eucalypt forest and woodland, abundances vary considerably, but are generally higher than abundances estimated in arid areas. Most densities reported in south-eastern Australian woodland, low-open forest and tall-open forest range from 12-24 birds/ha, with the greatest densities (30-35 birds/ha) recorded in tall open-forest (Recher 1985). Densities recorded in tall open-forest are comparable to densities estimated at Peery in riparian eucalypt woodland of major creeklines, the most mesic habitat in the study area.

A study of patterns, such as this, implies, but does not prove, links between factors and effects. Effects of drought need to be discerned from seasonal effects and inherent annual variation. Variables, such as flood cycles (which may be independent of local rainfall), the timing of rainfall, and fluctuations in predator populations, need to be considered. Given the

scale, complexity, variability and unpredictability of the arid environment, and the mobility of birds, it will be extremely difficult to design and implement truly meaningful experiments to elucidate community patterns and underlying processes. Much could be gained, however, by studying intensively populations at a range of sites over longer time periods, as suggested by Holmes *et al.* (1979).

Appendix 3.1. **Land bird species recorded at study site.** Figures in table indicate mean density of each species per 10 ha as recorded in census transects. The number in brackets indicates the number of transects (maximum 15) in which the species was recorded in that census period. **#** indicates species present at site but not recorded in census. Status of species refers to biogeographical origin (**B** Bassian, **E** Eyrean, **M** Multifaunal, **T** Torresian); movement status at site (**I** irregular nomad, **R** resident, **S** spring-summer migrant, **W** winter migrant); and feeding group (**A** aerial, **F** foliage, **Fl/F** flower/foliage, **G** ground, **G/A** ground/aerial, **G/B** ground/bark, **G/Fr** ground/fruit, **P** predator - live vertebrates and carrion). Species nomenclature follows Simpson & Day (1993).

| **Bird Species** | | **Status** | **Spring 1990** | **Winter 1991** | **Spring 1991** | **Winter 1992** | **Spring 1992** | **Autumn 1993** | **Winter 1993** | **Spring 1993** | **Summer 1993/94** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family DROMAIIDAE** | | | | | | | | | | | |
| Emu | *Dromaius novaehollandiae* | **E;R;G** | .09(1) | # | .13(1) | # | .09(1) | .04(1) | # | .53(4) | .13(2) |
| **Family ACCIPITRIDAE** | | | | | | | | | | | |
| Black-shouldered Kite | *Elanus notatus* | **M** | | | | | | | # | # | # |
| Black Kite | *Milvus nigrans* | **M** | | # | # | # | # | # | | | # |
| Black-breasted Buzzard | *Hamirostra melanosternon* | **T** | | | | # | # | # | | | |
| Collared Sparrowhawk | *Accipiter cirrhocephalus* | **M;R;P** | .04(1) | .13(2) | .18(4) | .20(2) | # | .31(3) | .04(1) | # | # |
| Wedge-tailed Eagle | *Aquila audax* | **M;R;P** | .04(1) | # | # | .04(1) | # | # | .09(1) | # | # |
| Spotted Harrier | *Circus assimilis* | **E** | | | | | | | | # | |
| **Family FALCONIDAE** | | | | | | | | | | | |
| Black Falcon | *Falco subniger* | **E** | | # | # | # | | | | | |
| Australian Hobby | *Falco longipennis* | **M;R;P** | .09(1) | # | # | # | # | # | # | # | |
| Brown Falcon | *Falco berigora* | **M** | # | | | | # | # | | | |
| Australian Kestrel | *Falco cenchroides* | **M;R;P** | .22(3) | # | # | # | .36(3) | # | | # | # |
| **Family PHASIANIDAE** | | | | | | | | | | | |
| Stubble Quail | *Coturnix pectoralis* | **B;I;G** | | | # | | | # | .13(1) | | .09(1) |
| Little Button-quail | *Turnix velox* | **E;I;G** | | | | | # | .09(1) | .31(1) | .27(4) | .11(2) |
| **Family COLUMBIDAE** | | | | | | | | | | | |
| *Feral Pigeon | *Columba livia* | | | | # | | | | | | |
| Peaceful Dove | *Geopelia livia* | **T;I;G** | | | .04(1) | .36(3) | .18(2) | # | | | |
| Diamond Dove | *Geopelia cuneata* | **E;I;G** | | | | # | # | 2.22(9) | .58(4) | 2.15(9) | .31(3) |
| Common Bronzewing | *Phaps chalcoptera* | **M** | | | | | | | | | # |
| Crested Pigeon | *Geophaps lophotes* | **E;R;G** | 2.8(10) | 2.10(9) | 2.36(11) | .96(10) | 2.36(11) | 3.51(8) | 2.02(9) | 1.47(8) | 3.33(13) |
| **Family PSITTACIDAE** | | | | | | | | | | | |
| Galah | *Cacatua roseicapilla* | **E;R;G/Fr** | 3.51(5) | # | .27(3) | 6.36(3) | 2.40(5) | 2.80(5) | 2.27(6) | .44(4) | .93(5) |
| Little Corella | *Cacatua pastinator* | **M;R;G/Fr** | .49(2) | # | # | # | 2.09(4) | 1.07(4) | 3.02(3) | .80(2) | 1.51(1) |
| Pink Cockatoo | *Cacatua leadbeateri* | **E;R;G** | .09(1) | # | # | .40(4) | # | # | | # | # |
| Cockatiel | *Leptolophus hollandicus* | **E;I;G** | | | # | | .04(1) | .09(1) | # | .49(5) | .44(1) |
| Budgerigar | *Melopsittacus undulatus* | **E;I;G/Fr** | # | | | | .67(2) | 32.09(6) | | 45.58(6) | |
| Mallee Ringneck | *Barnardius barnardi* | **E;R;G/Fr** | 4.80(9) | 1.96(5) | 2.89(10) | 1.38(7) | 1.47(9) | 2.13(6) | 1.69(6) | 1.47(5) | 1.38(5) |
| Mulga Parrot | *Psephotis varius* | **E;R;G** | 1.11(6) | 2.62(9) | .93(4) | .67(4) | .31(3) | # | .62(4) | .18(2) | .27(2) |
| Blue Bonnet | *Northiella haematogaster* | **E;R;G** | 7.02(12) | 2.44(9) | 2.84(10) | 2.80(9) | 1.62(8) | .80(4) | 1.60(6) | .71(3) | 1.20(3) |
| Blue-winged parrot | *Neophema chrysostoma* | **B** | | | | # | | # | | | |

Appendix 3.1 continued

| Bird species | | Status | Spring 1990 | Winter 1991 | Spring 1991 | Winter 1992 | Spring 1992 | Autumn 1993 | Winter 1993 | Spring 1993 | Summer 1993/94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family CUCULIDAE** | | | | | | | | | | | |
| Pallid Cuckoo | *Cuculus pallidus* | M;I;F | | | | | | .04(1) | # | .04(1) | # |
| Black-eared Cuckoo | *Chrysococcyx osculans* | E;I;F | .04(1) | | | | | | | # | |
| Horsfield's Bronze Cuckoo | *Chrysococcyx basalis* | M;S;F | .27(3) | | .04(1) | | # | .09(1) | .04(1) | # | |
| **Family STRIGIDAE** | | | | | | | | | | | |
| Southern Boobook | *Ninox novaeseelandiae* | M;W;P | | # | | | | .09(2) | .09(1) | | |
| **Family PODARGIDAE** | | | | | | | | | | | |
| Tawny Frogmouth | *Podargus strigoides* | M | # | # | | | | | | | |
| **Family AEGOTHELIDAE** | | | | | | | | | | | |
| Australian Owlet-nightjar | *Aegotheles cristatus* | M | # | # | # | # | # | # | # | # | # |
| **Family CAPRIMULGIDAE** | | | | | | | | | | | |
| Spotted Nightjar | *Eurostopodus argus* | M;R;A | | # | # | # | # | # | # | .04(1) | .04(1) |
| **Family APODIDAE** | | | | | | | | | | | |
| Swift | *(species unknown)* | M | | | | | | # | | | |
| **Family ALCEDINIDAE** | | | | | | | | | | | |
| Red backed Kingfisher | *Halycon pyrrhopygia* | E;S;G | .36(3) | | .36(3) | | # | | | .53(3) | .13(3) |
| Sacred Kingfisher | *Halycon sancta* | M;S;G | .18(3) | | # | | # | # | | .22(2) | .27(3) |
| **Family MEROPIDAE** | | | | | | | | | | | |
| Rainbow Bee-eater | *Merops ornatus* | T;S;A | 2.76(5) | | 3.33(7) | | 1.16(4) | | | .76(4) | .89(3) |
| **Family CLIMACTERIDAE** | | | | | | | | | | | |
| Brown Treecreeper | *Climacteris picumnis* | M;R;G/B | 3.51(3) | 1.78(2) | 2.22(2) | 1.11(2) | 1.60(2) | .89(2) | 1.64(3) | 1.69(2) | 1.33(3) |
| **Family MALURIDAE** | | | | | | | | | | | |
| Variegated Fairy-wren | *Malurus lamberti* | M;R;F | 5.02(5) | 3.84(4) | 4.62(6) | 3.31(5) | 2.09(5) | .82(3) | 1.16(3) | 2.91(5) | 2.00(7) |
| White-winged Fairy-wren | *Malurus leucopterus* | E;R;F | 3.40(1) | 2.22(2) | 1.27(1) | .67(1) | 1.27(1) | 2.07(2) | 2.24(3) | 2.51(2) | 3.42(2) |
| **Family MELIPHAGIDAE** | | | | | | | | | | | |
| Spiny-cheeked Honeyeater | *Acanthagenys rufogularis* | E;R;Fl/F | 7.64(11) | 4.16(12) | 2.53(9) | 8.49(8) | 1.93(7) | 1.11(6) | 2.27(9) | 1.64(10) | .53(6) |
| Little Friarbird | *Philemon citreogularis* | T;I;Fl/F | | | | .09(2) | | | | | |
| Yellow-throated Miner | *Manorina flavigula* | E;R;Fl/F | 9.11(11) | 5.78(9) | 16.22(10) | 6.04(9) | 1.56(8) | 7.47(7) | 6.02(10) | 4.67(9) | 5.91(12) |
| Singing Honeyeater | *Lichenostomus virescens* | E;R;Fl/F | .62(2) | .49(4) | .49(3) | .89(3) | .62(4) | .89(2) | 1.11(2) | .98(3) | 1.24(6) |
| Yellow-plumed Honeyeater | *Lichenostomus ornatus* | B;I;Fl/F | | | | .04(1) | | | | | |
| White-plumed Honeyeater | *Lichenostomus penicillatus* | E;R;Fl/F | 22.36(8) | 31.78(10) | 17.11(6) | 25.33(6) | 19.91(10) | 23.51(9) | 36.16(9) | 34.36(11) | 31.40(10) |
| White-fronted Honeyeater | *Phylidonyris albifrons* | E;I;Fl/F | | | | 4.18(2) | | | .67(1) | | |
| Black Honeyeater | *Certhionyx niger* | E;I;Fl/F | | | | | | .13(1) | .04(1) | | |
| Pied Honeyeater | *Certhionyx variegatus* | E;I;Fl/F | | | | | | | .31(1) | | |
| **Family EPTHIANURIDAE** | | | | | | | | | | | |
| Crimson Chat | *Ephthianura tricolor* | E;I:G | | # | 2.04(2) | | .14(2) | .13(1) | .31(1) | 4.61(8) | .71(2) |
| Orange Chat | *Ephthianura aurifrons* | E;I;G | | | | # | | .21(1) | | # | # |
| White-fronted Chat | *Ephthianura albifrons* | B;I;G | | | | | | | .13(1) | # | |
| **Family PARDALOTIDAE** | | | | | | | | | | | |
| Red-browed Pardalote | *Pardalotus rubricatus* | E | | # | | | | | | | |

Appendix 3.1 continued

| Bird species | | Status | Spring 1990 | Winter 1991 | Spring 1991 | Winter 1992 | Spring 1992 | Autumn 1993 | Winter 1993 | Spring 1993 | Summer 1993/94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Striated Pardalote | *Pardalotus striatus* | M;R;F | .36(3) | .53(4) | .58(4) | .31(2) | .31(3) | .09(1) | .22(4) | .09(1) | .13(2) |
| Weebill | *Smicornis brevirostris* | M;I;F | | | | # | .07(1) | | | | # |
| Western Gerygone | *Gerygone fusca* | E;I;F | | | | | | .04(1) | | | |
| Chestnut-rumped Thornbill | *Acanthiza uropygialis* | M;R;F | 4.40(4) | 1.82(6) | 1.20(6) | 2.27(6) | 2.02(6) | .64(3) | .53(2) | .40(2) | 1.11(4) |
| Yellow-rumped Thornbill | *Acanthiza chrysorrhoa* | M;R;G | 4.51(7) | 1.42(4) | .76(4) | .89(4) | 1.16(4) | .80(2) | .71(2) | .58(2) | # |
| Southern White face | *Aphelocephala leucopsis* | E;R;G | 4.40(8) | 2.98(8) | 2.20(9) | 2.89(8) | 2.80(7) | .53(3) | .80(6) | 1.02(5) | .71(4) |
| **Family EOPSALTRIIDAE** | | | | | | | | | | | |
| Red-capped Robin | *Petroica goodenovii* | E;W;G | .72(5) | .58(3) | .04(1) | .76(5) | .13(2) | .93(5) | .80(5) | # | |
| Hooded Robin | *Melanodryas cucullata* | M | | | | | | | | | # |
| **Family POMATOSTOMIDAE** | | | | | | | | | | | |
| Chestnut-crowned Babbler | *Pomatostomus ruficeps* | E;R;G | 5.33(6) | 2.40(6) | 4.53(6) | 1.78(4) | 3.07(5) | 3.82(4) | 2.40(6) | 2.27(4) | 2.36(5) |
| **Family CINCLOSOMIDAE** | | | | | | | | | | | |
| Chirrupping Wedgebill | *Psophodes cristatus* | E;I;G | .09(1) | .04(1) | # | | | | | | |
| **Family PACHYCEPHALIDAE** | | | | | | | | | | | |
| Crested Bellbird | *Oreoica gutturalis* | E;R:G | .18(1) | # | # | # | | | # | # | |
| Rufous Whistler | *Pachycephalus rufiventris* | M;R;F | # | # | 04(1) | 09(2) | # | 18(1) | 04(1) | | |
| Grey Shrike-thrush | *Colluricincla harmonica* | M;R;G/B | 1.02(5) | 1.47(4) | 1.07(3) | 1.24(3) | .84(3) | 1.11(2) | 1.56(3) | 1.29(3) | .62(3) |
| **Family MONARCHIDAE** | | | | | | | | | | | |
| Restless Flycatcher | *Myoagra inquieta* | M;W:A | | .18(2) | | | | .04(1) | .18(1) | | |
| Australian Magpie-lark | *Grallina cyanoleuca* | M;R;G | 5.24(11) | .44(5) | .98(4) | .53(3) | 1.42(7) | 1.42(7) | .67(6) | 1.47(8) | .89(8) |
| Grey Fantail | *Rhipidura fuliginosa* | M;W;A | | .44(3) | .09(1) | .22(1) | # | .22(2) | .04(1) | | |
| Willie Wagtail | *Rhipidura leucophrys* | M;R;G/A | 10.42(12) | 3.33(12) | 4.87(11) | 2.84(12) | 4.98(10) | 5.03(13) | 2.73(10) | 5.32(13) | 3.24(9) |
| **Family CAMPEPHAGIDAE** | | | | | | | | | | | |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | M;R;F | 1.33(8) | .09(1) | .58(4) | .22(3) | .58(6) | .38(3) | .36(4) | .71(7) | .44(5) |
| Ground Cuckoo-shrike | *Coracina maxima* | E | # | # | | | | | | | |
| White-winged Triller | *Lalage tricolor* | E;S;F | 1.42(6) | | .31(4) | | .98(4) | | | .62(3) | |
| **Family ORIOLIDAE** | | | | | | | | | | | |
| Olive-backed Oriole | *Oriolus sagittatus* | M | | | | | | | | # | |
| **Family PTILONORHYNCHIDAE** | | | | | | | | | | | |
| Spotted Bowerbird | *Chlamydera maculata* | E;I;Fl/F | | | | | | | | .09(1) | |
| **Family ARTAMIDAE** | | | | | | | | | | | |
| White-breasted Woodswallow | *Artamus leucorhynchus* | T;S;A | 1.15(4) | | .31(3) | | 1.33(4) | .16(2) | | 1.51(4) | .80(1) |
| Masked Woodswallow | *Artamus personatus* | E;I;A | | | | | .44(1) | | | | |
| White-browed Woodswallow | *Artamus superciliosus* | E;I;A | | | | | 4.31(6) | # | | 1.33(3) | |
| Black-faced Woodswallow | *Artamus cinereus* | T;R;G/A | .89(5) | .51(6) | .93(3) | .80(3) | .31(3) | # | 1.24(4) | .31(2) | 1.07(4) |
| Grey Butcherbird | *Cracticus torquatus* | M;W;P | | .18(2) | # | # | | # | .18(2) | | |
| Pied Butcherbird | *Cracticus nigrogularis* | T;R;P | .44(2) | .09(2) | .40(4) | .04(1) | .04(1) | .09(1) | .31(2) | # | # |
| Australian Magpie | *Gymnorhina tibicen* | B;R;G | .93(7) | .31(4) | .09(2) | .24(4) | .40(4) | .04(1) | .40(6) | .56(6) | .62(6) |
| **Family CORVIDAE** | | | | | | | | | | | |
| Australian Raven | *Corvus coronoides* | B;R;P | # | .09(2) | # | .09(1) | .27(2) | .27(2) | .13(1) | .36(3) | .04(1) |

Appendix 3.1 continued

| Bird species | | Status | Spring 1990 | Winter 1991 | Spring 1991 | Winter 1992 | Spring 1992 | Autumn 1993 | Winter 1993 | Spring 1993 | Summer 1993/94 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Crow | *Corvus bennetti* | **E;R;P** | .42(3) | .04(1) | .40(3) | # | .18(3) | # | .09(1) | .53(3) | .04(1) |
| **Family CORCORACIDAE** | | | | | | | | | | | |
| White-winged Chough | *Corcorax melanorhampos* | **B;R;G** | .76(2) | # | .18(1) | # | .27(1) | .84(3) | # | .49(2) | .53(1) |
| Apostlebird | *Struthidea cinerea* | **T;R;G** | 11.16(9) | 1.96(2) | 6.67(6) | 14.80(5) | 7.56(5) | 8.13(6) | 4.93(3) | 3.33(5) | 1.64(3) |
| **Family HIRUNDINIDAE** | | | | | | | | | | | |
| White-backed Swallow | *Cheramoeca leucosternum* | **E;R;A** | | # | .09(1) | | .14(2) | # | .22(1) | # | |
| Welcome Swallow | *Hirundo neoxena* | **B;R;A** | # | .22(3) | # | .09(1) | | # | # | | # |
| Tree Martin | *Hirundo nigricans* | **B;R;A** | 57.29(10) | 16.81(12) | 21.92(9) | .98(5) | 10.49(6) | 22.40(9) | 14.64(6) | 20.99(6) | 6.80(4) |
| Fairy Martin | *Hirundo ariel* | **M;I;A** | .44(1) | | | | | | | # | |
| **Family SYLVIIDAE** | | | | | | | | | | | |
| Rufous Songlark | *Cinclorhampus mathewsi* | **M;I;G** | .36(3) | # | | .04(1) | # | .18(3) | 1.18(6) | 5.36(9) | .13(1) |
| Brown Songlark | *Cinclorhampus cruralis* | **E;I;G** | .13(1) | | | | | # | | # | |
| **Family STURNIDAE** | | | | | | | | | | | |
| *Common Starling | *Sturnus vulgaris* | **I;G** | .47(4) | | # | | | | | | # |
| **Family MOTACILLIDAE** | | | | | | | | | | | |
| Richard's Pipit | *Anthus novaeseelandiae* | **M;R;G** | 1.52(4) | .10(2) | .28(4) | .23(4) | .22(3) | .04(1) | .04(1) | # | .13(2) |
| **Family DICAEIDAE** | | | | | | | | | | | |
| Mistletoebird | *Dicaeum hirundinaceum* | **M;I;Fl/F** | # | .04(1) | | # | # | .07(1) | | | |
| **Family PASSERIDAE** | | | | | | | | | | | |
| Zebra Finch | *Taeniopygia guttata* | **E;I;G** | 3.69(4) | .40(1) | | 3.78(1) | .76(2) | 50.29(11) | 12.73(8) | 5.89(11) | 7.40(6) |
| | | | | | | | | | | | |
| **TOTAL NO. OF LANDBIRD SPECIES** | | | **60** | **58** | **61** | **59** | **63** | **71** | **60** | **66** | **58** |

Chapter 4. **BIRDS ALONG A MESIC-XERIC GRADIENT OF CREEKLINE HABITATS**

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## 4.1 **Introduction**

Results of bird censuses presented in Chapter 3 have shown that creekline habitats at the study site support far more birds and more species than do adjacent run-off areas. This importance of creekline habitats to birds in arid areas is well recognised, for example, Pianka & Pianka (1970), Denny *et al.* (1977), Wyndham (1978), Brooker *et al.* (1979), Badman (1989) and Henle (1989). Creekline habitats are small in area, but their enhanced water supplies lead to a far greater regularity of plant growth than occurs in surrounding run-off areas (Ludwig 1987). They are the sites of most annual plant growth (Mott 1973), and they promote perennial plant growth in which the timing, if not the level, of production is regular (Davies 1976). Davies (1973, 1982) has suggested that sedentary birds persist in arid areas by virtue of such relatively mesic run-on habitats.

The important role of creekline habitats prompted me to make a detailed investigation of bird/habitat relationships in creeklines at the study site. These creeklines, as is typical of arid areas, form a continuum between those with permanent sub-surface water supplies and those with only ephemeral water supplies (Stafford Smith & Morton 1990). This continuum is reflected in the floristic and structural heterogeneity of their vegetation.

In this chapter, I ask if there are different bird communities along the creekline spectrum. If so, then how distinct are the communities? How do the communities differ in terms of species composition, are some communities dominated by nomadic, some by resident species? The differences found between run-on and run-off habitats in Chapter 3 suggest that the drier creeklines support fewer birds and fewer, but different, species than the more mesic creeklines.

I also ask which habitat attributes have the greatest influence on bird community patterns along the creekline continuum. I look at the influence of habitat variables on overall patterns in the avifauna and on the distribution of individual bird species. I investigate floristic and physiognomic habitat variables, since both might contribute to avifaunal composition (Mac Nally 1990). Finally, I compare the use of plant species by individual bird species.

## 4.2 **Study area**

A general description of the study area is provided in Chapter 2.

Catchments of creeks in the study area ranged from relatively small areas of open plain (Lignum and Prickly Wattle Creeks), to the adjacent Peery Hills (Goanna Gully and Camp Creeks), to more extensive low ranges north-west of the study area (Rutherfords and Box Creeks). All creek systems drain into Peery Lake (see Figure 2.3, Chapter 2).

Creekline habitats sampled extended from Peery Lake edge to a distance of 3.5 km upstream. The most mesic sections of creekline habitat were almost 200 m wide and supported eucalypt woodland dominated by River Red Gum and Black Box, with an understorey of River Cooba, Boobialla and Lignum (scientific names of plants mentioned in text are given in Table 4.1). As creeklines became increasingly ephemeral, the fringing strip of vegetation narrowed and eucalypts became sparser, eventually giving way to Whitewood, then, in the Peery Hills, to mixed low trees including Rosewood, Beefwood, Santalum and Mulga. On the open plains, the driest sections of creekline were treeless and shrubs such as Prickly Wattle and cassias dominated.

## 4.3 **Methods**

### 4.3.1 **Bird data**

Sixty-five 0.5 ha census plots were laid out to sample the range of environmental variation within creekline habitat. Plots were 100 m long and 50 m wide and their long axis was centred on the midline of creekbeds. Sets of plots formed transects 400 to 600 m long.

Plots were censused each winter (July) and spring (October) from 1991 to 1993 inclusive. In each period all plots were censused on five different mornings. The order of counts was varied to ensure that counts for a given plot were spread throughout the morning and census period. In each census I walked slowly through the transect, deviating from the centre line as necessary to search denser areas of vegetation and hence increase detection of more cryptic species. I took approximately five minutes to search each plot and record birds

seen or heard. Flying birds were not counted unless obviously foraging within the census area. Waterbirds associated with Peery Lake were occasionally encountered in plots, but were not included in analyses.

### 4.3.2 **Habitat data**

Thirty-five habitat attributes considered likely to influence the composition of the avifauna were measured in each census plot. Table 4.1 lists the habitat variables measured in each plot and indicates the mean value and range of values recorded for each variable.

The maximum height of vegetation was measured with a clinometer. The width of the linear strip of creekline habitat at the central point of each plot was measured with a tape. The species composition of the ten trees and ten shrubs closest to the central point of each plot was recorded. Distances of the furthest of the ten trees and ten shrubs from the central point were measured to enable estimation of the density of trees and shrubs and the density of individual plant species. The ground cover of plots was assessed visually and the cover of herbage, litter and stones were each ranked as sparse (<5% cover), low (5-20%), moderate (>20-40%) or high (>40%). Stone and litter cover were assessed in winter 1991. Herbage cover was more variable and was assessed in every census period. The mean value for the study period was then calculated for each plot. The foliage cover of perennial trees and shrubs in adjacent run-off habitat to a distance of 100 m on either side of the creekline habitat was ranked as nil, low (<5% cover), moderate (5-20% cover) or high (>20% cover). Distances of plots via creeklines to the margin of Peery Lake (peak flood level in the 1990 flood) were measured with a tape or calculated from aerial photography. The presence of pools of water within plots was noted in each count and summed overall to provide an index of the availability of surface water.

Table 4.1. **Summary of habitat variables measured in 65 creekline census plots.** Abbreviations used for each variable are given in parentheses.

| | MEAN | RANGE |
|---|---|---|
| **Density of perennial tree and shrub species (no./ha)** | | |
| Mulga *Acacia aneura* (ACANEU) | 3 | 0 - 64 |
| River Cooba *Acacia stenophylla* (ACSTEN) | 24 | 0 - 485 |
| Dead Finish *Acacia tetragonophylla* (ACTETR) | 4 | 0 - 75 |
| Prickly Wattle *Acacia victoriae* (ACVICT) | 17 | 0 - 273 |
| Rosewood *Alectryon oleifolius* (ALOLEI) | 8 | 0 - 426 |
| Whitewood *Atalaya hemiglauca* (ATHEMI) | 17 | 0 - 260 |
| Eurah *Eremophila bignoniflora* (ERBIGN) | 0.4 | 0 - 15 |
| Harlequin Eremophila *Eremophila duttonnii* (ERDUTT) | 0.4 | 0 - 24 |
| River Red Gum *Eucalyptus camaldulensis* (EUCAMA) | 38 | 0 - 432 |
| Blackbox *Eucalyptus largiflorens* (EULARG) | 21 | 0 - 432 |
| Beefwood *Grevillea striata* (GRSTRI) | 2 | 0 - 37 |
| Black Bluebush *Maireana pyramidata* (MAPYRA) | 5 | 0 - 122 |
| Lignum *Muehlenbeckia florulenta* (MUFLOR) | 146 | 0 - 5090 |
| Boobialla *Myoporum montanum* (MYMONT) | 533 | 0 - 9899 |
| Santalum *Santalum lanceolatum* (SALANC) | 3 | 0 - 88 |
| Spiny Fan-flower *Scaevola spinescens* (SCSPIN) | 4 | 0 - 75 |
| *Cassias Senna* spp. (SENNAS) | 31 | 0 - 453 |
| **Vegetation structure** | | |
| Maximum vegetation height (m) (HEIGHT) | 10 | 3 - 20 |
| Creekline vegetation width (m) (WIDTH) | 63 | 8 - 180 |
| Total trees (no./ha) (ALLTREES) | 102 | 4 - 440 |
| Total shrubs (no./ha) (ALLSHRUBS) | 970 | 6 - 14141 |
| Total trees + shrubs (no./ha) (ALLTR/SH) | 1071 | 69 - 14316 |
| Total live trees (no./ha) (LIVETR) | 82 | 0 - 308 |
| Dead shrubs (no./ha) (DEADSH) | 187 | 0 - 4242 |
| Dead trees (no./ha) (DEADTR) | 20 | 0 - 176 |
| Dead trees + shrubs (no./ha) (DEADTR/SH) | 207 | 0 - 4277 |
| Total live eucalypt trees (no./ha) (EUCS) | 45 | 0 - 236 |
| Total live non-eucalypt trees (no./ha) (NONEUCS) | 56 | 0 - 352 |
| Adjacent shrub cover (ranked) (ADSHRUBS) | | low-high |
| Adjacent tree cover (ranked) (ADTREES) | | low-high |
| **Ground cover characteristics** | | |
| Herbage (ranked) (HERBAGE) | | sparse-high |
| Litter (ranked) (LITTER) | | sparse-high |
| Stones (ranked) (STONES) | | sparse-high |
| **Other variables** | | |
| Water - no. of counts when present, maximum 30 (WATER) | 9 | 1 - 23 |
| Distance to lake via creeklines (100m) (LAKE) | 12 | 0 - 34 |

### 4.3.3 **Data analyses**

#### 4.3.3.1 **Identification of creekline bird community types and bird species types**

Creekline bird community types (sets of plots with similar bird communities) and bird species types (sets of species with similar distribution patterns) were identified using multivariate cluster analyses. Bird data (number of individuals of each species in each plot summed over the three winter and three spring census periods) were transformed with $\log_{10}(x+1)$. Transformation meant that less emphasis was placed on bird abundance and more on species composition in comparisons between plots. It allowed for more meaningful comparison of species which were naturally gregarious, such as the Apostlebird and White-winged Chough, with more solitary species, such as the Pied Butcherbird, White-winged Triller and Grey Fantail, yet provided more information than can be given by simple presence/absence data. Species for which ten or fewer individuals were counted overall were excluded from analyses.

The dissimilarity between each pair of census plots, in terms of their avifauna, and between each pair of bird species, in terms of their occurrence and abundance in plots, was calculated using the Bray & Curtis association measure. The Bray & Curtis measure is robust to variations in models of species distribution (Faith *et al.* 1987). It has a ratio response and hence species with small differences in high abundance values contribute more to similarity of samples than close matches of lower values. It does not consider joint absences of species as adding to the similarity of sites.

A hierarchical agglomerative clustering strategy, flexible unweighted pair group arithmetic averaging (UPGMA) with $\beta = -0.1$ (Belbin 1990) was used to classify plots and birds. Dendrograms were drawn to display the history of classifications.

#### 4.3.3.2 **Comparison of the identified creekline bird communities**

A two-way table was constructed to illustrate the relationships between creekline bird community types and bird species types. Species numbers and bird densities, and the relative importance of resident, nomadic and migratory species, in each bird community type were

calculated.

#### 4.3.3.3 **Relationships between habitat variables and general bird distribution patterns**

Hybrid multidimensional scaling (Belbin 1990) was used to derive an ordination pattern illustrating the dissimilarity of census plots in terms of the composition of their avifauna. Comparisons of ordination methods and computer simulations have shown multidimensional scaling methods to be the most robust, and hybrid multidimensional scaling (which combines metric and non-metric scaling) to be more robust than non-metric multidimensional scaling (Minchin 1987, Faith & Norris 1989). Selection of the dimensionality (number of axes) of the ordination took account of the stress, or goodness of fit, of the ordination (Kruskal & Wish 1978). The stress of an ordination decreases with increasing dimensionality, but too many dimensions may add superfluous noise (Belbin 1990).

Principal axis correlation (PCC), a multiple linear regression program (Belbin 1990), was used to interpret the ordination space in terms of habitat attributes. PCC determines the linear relationship between habitat attributes and an ordination space. PCC searches in all directions for the line of best fit of each habitat variable and gives its correlation with that direction. It considers habitat attributes separately and so is not affected by correlations between variables. The statistical significance of correlations was tested with a Monte Carlo study (Faith 1991). The order of values of each habitat attribute was in turn randomised. The maximum linear correlation of each attribute with the ordination space was again computed to test if an equivalent or better correlation could be produced by chance alone. The procedure was repeated 99 times. A habitat correlation was regarded as non-significant if two or more of the 99 random correlations were as high as the observed correlation.

The Spearman Rank Correlation Coefficient was used to test correlations between habitat variables. This non-parametric method was used because a test for normality (Minitab Inc. 1989) based on the correlations of the distribution and normal probability plots of all habitat data sets (essentially equivalent to the Shapiro-Wilk test) indicated that most habitat data did not fit a normal distribution and could not be normalised through transformation.

#### 4.3.3.4 **Relationships between habitat variables and individual bird species**

Simple linear regression was used to determine which habitat variables were significantly related to abundance of the more common birds in creeklines. Bird count data were log transformed to obtain normal distributions.

The large number of relationships being tested increased the probability of finding significant results due to chance. This chance effect may be reduced by implementing a Bonferroni adjustment, that is, dividing the accepted significance level by the number of tests performed. The Bonferroni adjustment is conservative (Kirby 1993), and the size of the adjustment can be varied according to the number of tests of interest. For each species I recorded habitat variables significant at a level determined by dividing 0.05 by the number of habitat variables which were significant at $p < 0.05$.

The use of plant species by individual bird species was determined by observation during censuses. For all individuals sighted in counts I noted if they were first encountered on the ground, flying or in dead or live vegetation. If in vegetation, I also recorded the plant species.

## 4.4 **Results**

### 4.4.1 **Creekline bird community types and bird species types**

Seventy-three of the 95 native landbirds noted at Peery over the survey period were recorded in creekline censuses (Table 4.2). These included 41 residents, six spring-summer migrants, five winter migrants, and 21 nomads (Chapter 3). Most common overall were the White-plumed Honeyeater, Tree Martin, Yellow-throated Miner, Budgerigar and Apostlebird. The total number of species recorded overall in an individual plot ranged from nine to 28 and the total number of individuals from 49 to 615. For 24 species, fewer than 11 individuals were recorded overall. These occurrences were considered too infrequent for useful analysis and the 24 species were excluded from all analyses. These birds included cryptic nocturnal species, species that were rare in the region, and species that usually occurred in non-creekline habitats.

Table 4.2. **Birds recorded in creekline census plots.** Figures are total number of individuals counted in creeklines in three spring and three winter survey periods.

| *Residents:* | | *Spring-summer migrants:* | |
|---|---|---|---|
| White-plumed Honeyeater | 4210 | Rainbow Bee-eater | 128 |
| Tree Martin | 1846 | White-breasted Woodswallow | 45 |
| Yellow-throated Miner | 1257 | White-winged Triller | 43 |
| Apostlebird | 1106 | Red-backed Kingfisher | 21 |
| Willie Wagtail | 547 | Sacred Kingfisher | 5 |
| Chestnut-crowned Babbler | 499 | Horsfield's Bronze Cuckoo | 4 |
| Variegated Fairy-wren | 405 | | |
| Spiny-cheeked Honeyeater | 400 | *Winter migrants:* | |
| Blue Bonnet | 339 | Red-capped Robin | 23 |
| Crested Pigeon | 325 | Grey Fantail | 23 |
| Galah | 294 | Grey Butcherbird | 6 |
| Mallee Ringneck | 260 | Southern Boobook | 4 |
| Brown Treecreeper | 234 | Restless Flycatcher | 1 |
| Southern Whiteface | 233 | | |
| Grey-shrike Thrush | 190 | *Nomads:* | |
| Singing Honeyeater | 176 | Budgerigar | 1181 |
| White-winged Fairy-wren | 161 | Zebra Finch | 533 |
| Chestnut-rumped Thornbill | 142 | Rufous Songlark | 172 |
| Little Corella | 137 | White-browed Woodswallow | 124 |
| Australian Magpie-lark | 123 | Crimson Chat | 118 |
| Mulga Parrot | 108 | Diamond Dove | 65 |
| Yellow-rumped Thornbill | 106 | Cockatiel | 38 |
| Black-faced Woodswallow | 99 | White-fronted Honeyeater | 22 |
| Striated Pardalote | 76 | Masked Woodswallow | 12 |
| Black-faced Cuckoo-shrike | 65 | Peaceful Dove | 11 |
| Australian Magpie | 54 | Little Button-quail | 3 |
| Australian Raven | 31 | Stubble Quail | 3 |
| Little Crow | 30 | Brown Songlark | 2 |
| White-winged Chough | 30 | Little Friarbird | 2 |
| Pied Butcherbird | 27 | Yellow-plumed Honeyeater | 2 |
| Emu | 24 | Weebill | 2 |
| Pink Cockatoo | 14 | Spotted Bowerbird | 2 |
| Collared Sparrowhawk | 12 | Chirrupping Wedgebill | 1 |
| Australian Kestrel | 10 | Red-browed Pardalote | 1 |
| Wedge-tailed Eagle | 9 | Mistletoebird | 1 |
| Rufous Whistler | 8 | Black Honeyeater | 1 |
| White-backed Swallow | 8 | | |
| Welcome Swallow | 7 | | |
| Richard's Pipit | 4 | | |
| Crested Bellbird | 3 | | |
| Spotted Nightjar | 1 | | |

The UPGMA analysis distinguished four major bird community types (Figure 4.1) within creekline habitat. The wide fringe of relatively tall eucalypt woodland along the lower reaches of major creeklines supported the most distinctive bird community type (hereafter referred to as the 'eucalypt' bird community). The minor creeklines and the upper reaches of major creeklines supported three more closely related bird community types: that associated with creekline supporting dense shrubs, especially Lignum and Prickly Wattle, but only very occasional trees ('shrub' bird community); that associated with creekline with moderately tall woodland dominated by Whitewood and in which eucalypts were occasional ('Whitewood/sparse eucalypt' bird community); and that associated with creekline surrounded by tall shrubland and supporting mixed low trees including Mulga, Beefwood, Whitewood, Dead Finish and only very occasional eucalypts ('mixed low tree' bird community).

The classification of bird species, in terms of their distribution in creeklines, indicated two small and one large bird groups (designated groups one, two and three), and an additional nine species with various distribution patterns (Figure 4.2). Group 1 comprised the resident Singing Honeyeater, Black-faced Woodswallow and Chestnut-crowned Babbler, spring-summer migratory White-winged Triller, and nomadic White-fronted Honeyeater, Zebra Finch and Crimson Chat. In creeklines, these species tended to be associated with non-eucalypt vegetation. Group 2 comprised the resident White-winged and Variegated Fairy-wrens, Yellow-rumped and Chestnut-rumped Thornbills, Southern Whiteface, Australian Magpie, and winter migratory Red-capped Robin and Grey Fantail. Apart from the Australian Magpie, these are all small birds of the shrub and ground layers. Group 3 included 25 species (19 residents, two spring-summer migrants and four nomads) which were variously associated with eucalypts in creeklines. The nine miscellaneous species in the classification all occurred only sporadically in censuses.

### 4.4.2 **Comparison of the avifauna of the four creekline bird community types**

The bird species composition and occurrence of bird species groups in each of the four creekline bird community types are summarised in a two-way table (Table 4.3). The ordering of census plots and bird species in the table is derived from the multivariate classifications

Figure 4.1. **Identification of bird community types within creekline habitat.** The dendrogram illustrates the history of the UPGMA classification.

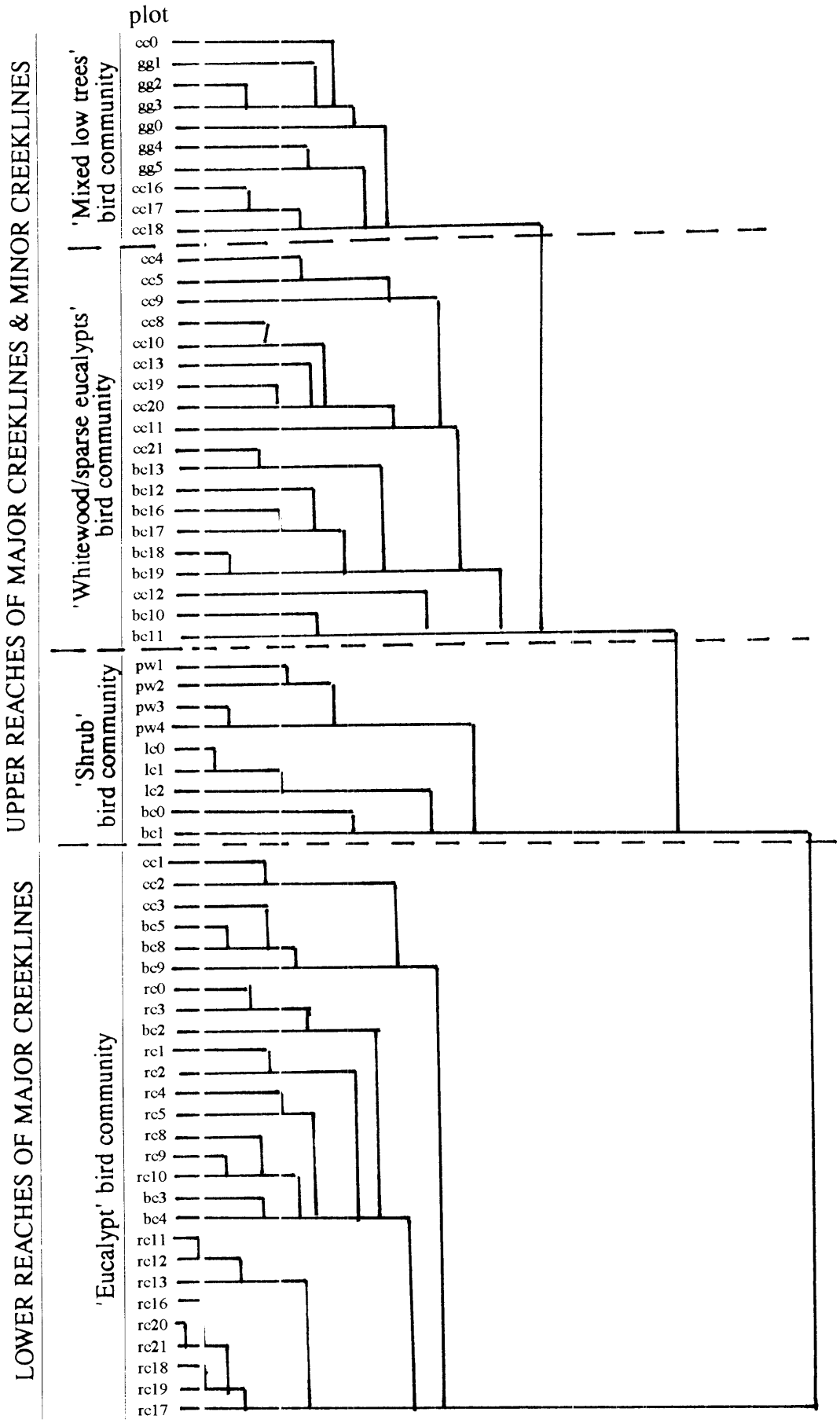


Figure 4.2. **Identification of bird species types based on their distribution within creekline habitat.** The dendrogram illustrates the history of the UPGMA classification.

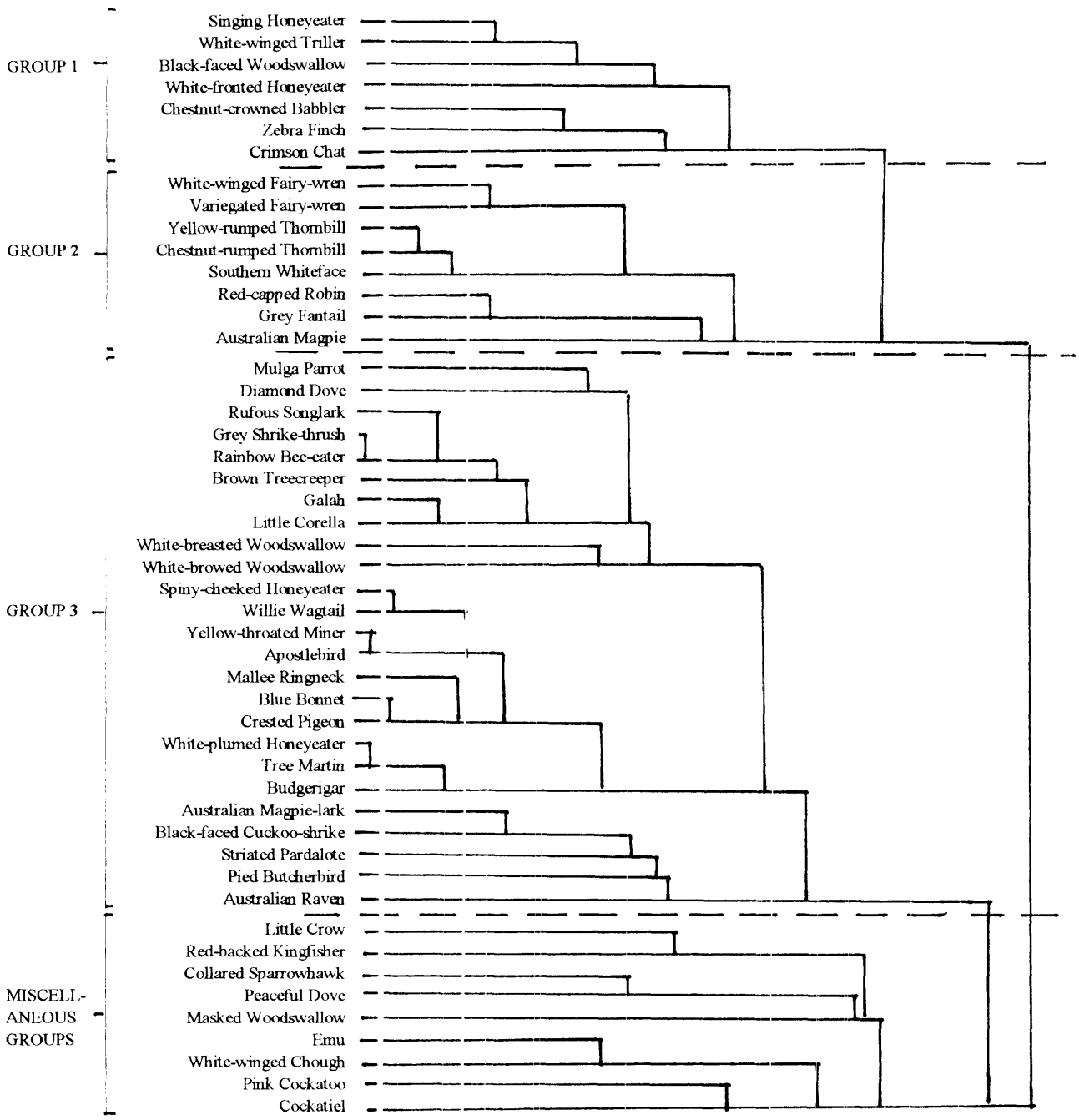


Table 4.3. **Relationships between bird community types and bird species identified in the UPGMA analysis.** The ordering of census plots and bird species follows the dendrograms (Figures 4.1 & 4.2). The complete matrix of abundance values has been standardised and values range from zero (blank) to five. The table includes resident species (ordinary type), migratory species (underlined) and nomads (bold type).

| BIRD COMMUNITY TYPES | PLOT | GROUP 1 | | | | | | | GROUP 2 | | | | | | | | GROUP 3 | | | | | | | | | | | | | | | | | | | | | | | | | MISCELLANEOUS GROUPS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Singing Honeyeater | White-winged Triller | Black-faced Woodswallow | **White-fronted Honeyeater** | Chestnut-crowned Babbler | **Zebra Finch** | **Crimson Chat** | White-winged Fairy-wren | Variegated Fairy-wren | Yellow-rumped Thornbill | Chestnut-rumped Thornbill | Southern Whiteface | Red-capped Robin | Grey Fantail | Australian Magpie | Mulga Parrot | **Diamond Dove** | **Rufous Songlark** | Grey Shrike-thrush | Rainbow Bee-eater | Brown Treecreeper | Galah | Little Corella | White-breasted Woodswallow | **White-browed Woodswallow** | Spiny-cheeked Honeyeater | Willie Wagtail | Yellow-throated Miner | Apostlebird | Mallee Ringneck | Blue Bonnet | Crested Pigeon | White-plumed Honeyeater | Tree Martin | **Budgerigar** | Australian Magpie-lark | Black-faced Cickoo-shrike | Striated Pardalote | Pied Butcherbird | Australian Raven | Little Crow | Red-backed Kingfisher | Collared Sparrowhawk | **Peaceful Dove** | **Masked Woodswallow** | Emu | White-winged Chough | Pink Cockatoo | **Cockatiel** |
| 'Mixed low trees' | cc0 | | | | | 2 | 1 | 3 | | 4 | | | | 1 | 2 | | 2 | 2 | 2 | | 1 | | | | | | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 1 | 1 | | | | | | | | | | | | | |
| | gg1 | | 1 | 2 | | 2 | 2 | 1 | | 3 | 2 | 3 | 3 | | | | | 1 | 2 | | 2 | | | | | | 3 | 3 | 2 | 4 | 2 | | 2 | 2 | 2 | | | | 2 | | 1 | 2 | | | | | | | | |
| | gg2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | | | 2 | 2 | 2 | 1 | | 1 | 2 | 1 | 2 | | | | | | | | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | | | | | | | | 1 | | | | | | | |
| | gg3 | 2 | 1 | 2 | 1 | 3 | 3 | 3 | | 2 | | 1 | 2 | 1 | | | 2 | | 2 | | | | | | | | 2 | 2 | 2 | | 1 | 2 | | 2 | 2 | | | | | | 1 | 1 | | | | | | | | |
| | gg0 | | | | | 2 | 3 | | | 2 | 2 | 2 | 2 | 1 | | | 2 | 1 | 1 | | | | 2 | | | | 1 | 2 | 2 | | 3 | | 2 | 2 | 2 | | | | 2 | | 2 | | 1 | | | | | | | |
| | gg4 | 2 | | 1 | 1 | 3 | 4 | 1 | | | | | 2 | | | | 2 | | 2 | | | | | | | | 3 | 1 | 1 | | | | 2 | | 1 | | | | | | | | | | | | | | | |
| | gg5 | 3 | | 2 | 2 | 3 | 2 | 1 | | | | | 2 | | | | | 1 | 1 | | 1 | | | | | | 3 | 2 | 3 | 3 | 2 | | 2 | 1 | 1 | | | | | | | | | | | | | | | |
| | cc16 | 2 | 1 | 3 | | 3 | 3 | 3 | | 2 | | 1 | 2 | | | | 1 | 1 | 2 | | | | | | | | 1 | 2 | 2 | 2 | | 2 | 2 | | | 4 | | | | | | | | | | | | | | |
| | cc17 | 2 | 2 | 2 | | 2 | 3 | | | | | | 2 | | | | 1 | 1 | 1 | | | | | | | | 2 | 2 | 3 | 2 | 2 | 2 | 2 | | | 1 | | | | | | | | | | | 1 | | 1 | |
| | cc18 | 1 | 1 | 2 | 1 | 2 | 3 | | | 2 | | 2 | 2 | | | 1 | | | | | | | | | | | 2 | 2 | 3 | | 1 | 2 | 2 | | | | | | | | | | | | | | | | 1 | 1 |
| 'Whitewood/sparse eucalypts' | cc4 | | 2 | | | 2 | 2 | | | | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | | | 1 | | 1 | 1 | | | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | | | 2 | | | | | | | | | | |
| | cc5 | 2 | 2 | | | 2 | 2 | | | | 2 | 3 | 2 | 1 | 2 | | 1 | | | | | | 1 | | | | | 3 | 3 | 2 | | 1 | | 2 | 1 | | | 1 | 1 | 1 | | 2 | | | | | | | 1 | |
| | cc9 | 1 | 2 | 1 | | | | | | | | 2 | 1 | 1 | | | | 1 | | | | | | | | | 1 | 2 | 2 | 3 | | 1 | 1 | | 1 | | 1 | 1 | 2 | 1 | | | 1 | | | | | | | |
| | cc8 | 1 | 1 | | | 2 | | | | | 1 | | 1 | | | 1 | | | | | | | | | | | 1 | 2 | 3 | 3 | 3 | | 2 | | 2 | | 2 | | 1 | | | | | | | | | | | |
| | cc10 | | 2 | 2 | | 2 | | | | | | | 2 | | | | 2 | | | | 1 | | | | | | 2 | 2 | 3 | 4 | 2 | 1 | 2 | | 1 | | 2 | 1 | 1 | | | | | | | | | | | |
| | cc13 | 2 | 1 | | | 3 | | | | 1 | | | | | | | 2 | | | | | | | | | | 2 | 1 | 3 | 2 | 2 | 2 | 2 | | 1 | | | | | | | 1 | 2 | | | | | | | |
| | cc19 | 2 | 2 | 2 | 1 | 3 | | | | | | 2 | | | | | | | 1 | | | | | | | | 2 | 2 | 3 | 2 | 2 | 2 | 3 | | | | 2 | 2 | | | | | | | | | | | 1 | |
| | cc20 | 1 | 1 | | | 3 | 2 | | | | | | | | | | | | | | | | | | | | 2 | 2 | 3 | 2 | 2 | | 1 | | | | 1 | 1 | | | | | | | | | | | | |
| | cc11 | | | 2 | | 3 | 2 | | | | | 1 | | | | | 2 | | | | | | | | | | | | 3 | 2 | 1 | 2 | 2 | | | | | | | | | | | | | | | | | 1 |
| | cc21 | | | | | | | | | | | 1 | | | | 2 | | | | | | | | 1 | | | | | 3 | 2 | 3 | 3 | 2 | | | | | | | | | 1 | | | | | | | | |
| | bc13 | | | | | 1 | | | | | | | | | | 2 | | | | | | | 1 | | | | | | 3 | 3 | 2 | 2 | 2 | | | | 1 | | 1 | | | | | | | | 1 | | | |
| | bc12 | | | | | | | | | | 2 | 1 | 1 | 1 | 1 | | | | | | | | | | | | 1 | | 3 | 3 | 2 | 3 | 3 | | | | | 1 | 2 | 1 | 1 | | | | | | 1 | | | |
| | bc16 | | | | | 3 | | | | | 2 | 1 | | | 1 | | | | | | | | | | | | 1 | 2 | 3 | 2 | 2 | 2 | 2 | | 1 | | 2 | | 1 | | | | | | | | 2 | | | |
| | bc17 | | | | | 3 | | | | 2 | 2 | 2 | 2 | 2 | 1 | 1 | | | | | | | 1 | | | | | 2 | 3 | 2 | 2 | 3 | 3 | | | | | | 2 | | | | | | | | | | | |
| | bc18 | | | | | 2 | | 1 | | 2 | 2 | 2 | 2 | 1 | | 2 | | | | | | | | | | | 1 | | 3 | 2 | 1 | 2 | 2 | | | | 1 | | | | | | | | | | 1 | | | |
| | bc19 | | 1 | | | 3 | | 2 | 2 | 2 | 2 | 1 | 2 | | | | | | | | | | | | | | 1 | 1 | 3 | | | 3 | 2 | | | | | | | | | | | | | | 1 | | | |
| | cc12 | | | | | | | | | | | | | | | 2 | | | | | | | | | | | | | 3 | 4 | | 1 | 2 | | 2 | | 1 | | | | | 2 | 2 | | | | | | | |
| | bc10 | | | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | 3 | 2 | | 2 | 2 | 3 | 1 | | 2 | | 2 | | 2 | | | | | | | | | |
| | bc11 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 3 | 2 | | 1 | 2 | 1 | | | 1 | 1 | 1 | 1 | 2 | | | | | | | | | |
| 'Shrub' | pw1 | | | | | | | | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 1 | 1 | | | | | | | | | | 2 | 2 | 2 | | | | 1 | 2 | 2 | | | | 1 | | | | | | | | | | | |
| | pw2 | | | | | 2 | 2 | | 2 | 3 | 2 | 2 | 3 | | 1 | | | | | | | | | | | | 2 | 1 | 3 | | 2 | | | 2 | 2 | | | | | 1 | | | | | | | | | | |
| | pw3 | | | | | | 1 | | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | | | | | | | | | | | 1 | | 3 | 3 | 2 | 1 | 2 | 1 | 2 | | | | | | | | | | | | | | | |
| | pw4 | 1 | | 2 | | 2 | 2 | | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | | 1 | | | | | | | | | 2 | 2 | 2 | 3 | 1 | | 2 | | 1 | | | | | | | | | | | | | | | |
| | lc0 | | | | | | 2 | | 3 | 3 | 2 | | 2 | | | 2 | | | | 1 | | | | | | | 2 | 3 | | | | | 2 | 3 | | | | | | | | | | | | | | | | |
| | lc1 | | | | | | 1 | | 3 | 3 | | 1 | 2 | | | | | | | 1 | | | | | | | 1 | 2 | 1 | | | | 2 | 3 | | | | | | | | | | 1 | | | | | | |
| | lc2 | | | | | | 3 | 2 | 3 | 3 | 2 | | 3 | | | | | | 1 | | | | | | | | 2 | 2 | | | | | 1 | 3 | 1 | 2 | | | | | | | | | | | | | | |
| | bc0 | | | | | | | | 1 | 2 | | | 2 | | | | | | | | | | 2 | 2 | | | | 1 | | | | 2 | 2 | 2 | 1 | | | 1 | | | | | | | | | | | | |
| | bc1 | | | | | | | | 2 | 4 | | | 1 | | 1 | 1 | | | | | 1 | | | | | | 1 | 1 | | | | 2 | 2 | 3 | 1 | | 1 | 1 | | | | | | | | | | | | 2 |
| 'Eucalypt' | cc1 | | | | | | | 1 | | 1 | | | | | | | | | 1 | | | | | | 1 | | 1 | 2 | 2 | 3 | | | 1 | 3 | 1 | 2 | | 2 | | | | | | | | | 1 | | | |
| | cc2 | | | | | | 1 | 1 | | 2 | | | | | | 1 | | 2 | 2 | | | | 1 | | | | 2 | 3 | 2 | | | | 1 | 4 | 1 | 2 | | 2 | 1 | | | | | 1 | | | | | | |
| | cc3 | | | | | | | | | | | 2 | | | | | 2 | | 1 | | 1 | | | | | | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 4 | 1 | 3 | 2 | 2 | 1 | | | | 1 | | | | | | | |
| | bc5 | | | | | 2 | | 2 | | | | | | | | | | 2 | 2 | 2 | 2 | 1 | | | | 2 | 3 | 3 | 4 | 3 | 2 | 3 | 2 | 4 | 1 | 3 | 2 | 2 | | | | | | | | | | | | 2 |
| | bc8 | | | | | | 2 | 1 | | | | | | | | | | 1 | 1 | 2 | 1 | 1 | | | | 3 | 2 | 3 | 3 | 3 | 1 | 2 | 2 | 4 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | | | | | | | 2 | | |
| | bc9 | | | | | | | | | | | | | | | | | 1 | | 1 | | 1 | | | | 1 | 1 | 2 | 3 | 3 | 1 | 1 | 1 | 4 | 2 | 2 | 2 | | 2 | 2 | | | | | | | | | | |
| | rc0 | | | | | | 2 | | | 2 | | | | | | 1 | | 1 | 2 | 3 | 2 | | 4 | 2 | 1 | | 2 | 3 | 2 | | | | 2 | 5 | 2 | 2 | 2 | 1 | | | 1 | 1 | 1 | | 2 | | | | | |
| | rc3 | | | | | | | | | | | | | | | | | 1 | 2 | 3 | 1 | | 3 | 3 | | 1 | 3 | 2 | 2 | | | | 2 | 5 | 3 | | 2 | 1 | | 2 | 1 | | | | 1 | | | | | |
| | bc2 | | | | | | | | | 2 | | | | | | 1 | | 1 | 2 | 2 | 2 | 1 | 2 | | | | 2 | 2 | 2 | | | 2 | | 4 | 3 | | 2 | 1 | | 1 | | | 1 | | | 1 | | | | 2 |
| | rc1 | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | 2 | | | | 1 | 1 | 3 | 2 | 2 | | | 5 | 2 | | 1 | 1 | | | 2 | | | | | | | | | |
| | rc2 | | | | | | 1 | | | | | | | | | 2 | | 1 | 1 | 2 | 2 | | 1 | 2 | | | 1 | 2 | 3 | 3 | | | | 5 | 3 | | | | | | 1 | | | 1 | 1 | | | | | |
| | rc4 | | | 1 | | | | | | | | | | | | | 1 | | 2 | 3 | 2 | | | | 2 | 3 | 3 | 2 | 4 | 2 | 2 | | | 5 | 4 | 3 | 1 | 1 | | 1 | 2 | | | 1 | | 2 | | | | |
| | rc5 | | | | | | | | | | | | | | | | 2 | | | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 3 | 4 | 3 | | | | 5 | 3 | 3 | 1 | | | | 1 | 1 | | | | | 2 | 2 | 2 | 1 |
| | rc8 | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 3 | 2 | 2 | 1 | | 1 | | 3 | 3 | 2 | 1 | 2 | 5 | 4 | 3 | 2 | 1 | | | | | | 1 | | | 2 | 2 | | |
| | rc9 | | | | | | | | | | | | | | | | 2 | 1 | 2 | 2 | 3 | 3 | 2 | | | 2 | 2 | 2 | 1 | 3 | 2 | | | 4 | 4 | 3 | | | | | | | 1 | 1 | | | | 1 | | |
| | rc10 | | | | | | | | | | | | | | | | 1 | 1 | 2 | 2 | 1 | 3 | | | | | 2 | 2 | 3 | 3 | 2 | | 2 | 4 | 3 | 2 | | 2 | | | | | | 1 | 1 | | | 1 | | |
| | bc3 | | | | | | | | | | | | | | | 2 | | | 2 | 2 | 2 | 1 | 3 | | | | 2 | 3 | 3 | 2 | 1 | 1 | 2 | 4 | 3 | 1 | 1 | 1 | | 1 | | 1 | | | | | 1 | | 1 | |
| | bc4 | | | 1 | | | 1 | | | | | | | | | | | 1 | 2 | 1 | 1 | 1 | | | | 1 | 2 | 2 | 3 | 4 | 2 | 1 | 1 | 4 | 3 | 1 | 1 | | 1 | 1 | | | | 1 | | 1 | 2 | 2 | | |
| | rc11 | | | 2 | | | 4 | | | | | | | | | | 2 | 1 | 2 | 2 | 2 | 3 | 3 | | | | 1 | 2 | 2 | | 1 | 1 | 2 | 4 | 4 | 4 | 1 | 1 | | 1 | 1 | | | 1 | | | | | | |
| | rc12 | | | 2 | | | 2 | | | | | | | | | | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | | 2 | | 3 | 3 | | 2 | 2 | 2 | 4 | 4 | 3 | 2 | 1 | | 1 | | 1 | | 1 | 1 | | | 2 | | |
| | rc13 | | 1 | | | | 3 | 2 | | | | | | | | | 2 | 2 | 2 | 2 | | 3 | 3 | 2 | 2 | 2 | 1 | 3 | 3 | 1 | 2 | 1 | 1 | 4 | 4 | 4 | 2 | | | | | | 1 | 1 | | | | | 1 | |
| | rc16 | | | | | | | 1 | | | | | | | | | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 4 | 4 | 4 | 2 | 2 | 2 | | | 2 | | | | | | | | |
| | rc20 | | | | | | | 2 | | | | | | | | | | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 4 | 4 | 2 | | 1 | | 1 | | | | | | | | | |
| | rc21 | | | | | | 1 | 1 | | | | | | | | | 1 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 2 | | | 3 | 2 | 3 | 2 | 2 | | 4 | 4 | 4 | 2 | 2 | 2 | | 1 | | | | | | | | 1 | 1 |
| | rc18 | | | | | | 1 | | | | | | | | | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 4 | 4 | | 1 | 1 | | | | | | 1 | | | | | |
| | rc19 | | | | | | 1 | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | | | 3 | 1 | 3 | 1 | 2 | 1 | 4 | 4 | 4 | 1 | | 1 | | | | | | | | | | | 1 |
| | rc17 | | | | | | | 1 | | | | | | | | | 1 | | 1 | 2 | 2 | 3 | 2 | | | 2 | | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 4 | 4 | 2 | 1 | | | | | | 1 | 1 | | | | | 2 |

(Figures 4.1, 4.2).

Almost half the birds (22/49) occurred in all four community types. Only six species were restricted to a single community: two residents (White-winged Chough and Brown Treecreeper), one spring-summer migrant (White-breasted Woodswallow), and three nomads (White-browed and Masked Woodswallows and Peaceful Dove), were restricted to the eucalypt bird community. Each bird species group was associated with more than one bird community type.

Group 1 was most abundant in the mixed low tree community and relatively common in the Whitewood/sparse eucalypt community, especially where Whitewoods predominated. Of this group, the Zebra Finch extended most frequently into the shrub and eucalypt communities. The Crimson Chat also occurred, though to a lesser extent, in the eucalypt community. Group 2 characteristically occurred in the shrub community, but spread into the mixed low tree and Whitewood/sparse eucalypt communities where there was a substantial shrub layer. Apart from the Australian Magpie, birds in this group were absent from the relatively mesic sections of creekline with dense eucalypts, although occasional Variegated Fairy-wrens and Chestnut-rumped Thornbills were recorded in shrubs within eucalypt woodland. Group 3 birds were linked by their concurrence in the eucalypt community, but differed in the extent to which they occurred elsewhere. Six species (listed above) were restricted to this community. Some species, such as the Tree Martin, Budgerigar, Australian Magpie-lark, Black-faced Cuckoo-shrike, Striated Pardalote, Pied Butcherbird and Australian Raven, occurred in non-eucalypt communities as well, but were most common in the eucalypt community. Others, for example the Spiny-cheeked Honeyeater, Willie Wagtail, Yellow-throated Miner, Apostlebird, Mallee Ringneck, Blue Bonnet and Crested Pigeon, were about equally common in all communities. There was a broad association between the nine miscellaneous species and the eucalypt community, but all these species are uncommon (none receives an abundance ranking greater than two) and the association is weak.

The eucalypt bird community easily supported the densest populations of birds (Figure 4.3). Five species, the White-plumed Honeyeater, Tree Martin, Yellow-throated Miner, Apostlebird and Budgerigar, accounted for 68% of individuals recorded in this community. The other communities did not contain species that were especially dominant

numerically. The eucalypt community and the mixed low tree community supported more species per plot than the shrub and Whitewood/sparse eucalypts communities (Figure 4.4).

Overall, all bird community types were dominated by resident birds and resident species (Table 4.4). Migratory birds were recorded in each community, but comprised no more than one per cent of all birds recorded in a community. The proportion of migratory species in each community type was similar, ranging from 8-14% Nomads were most numerous in the eucalypt bird community. The proportion of nomads in the eucalypt bird community ranged from none in winter 1991, when nomads were absent from the site, to 61% in spring 1993, in portions of Rutherford Creek where Budgerigars were especially numerous. Overall, nomads averaged 10% of all birds recorded in the eucalypt bird community over the study period. Nomads averaged 6% of all birds recorded in the mixed low tree community. The most common nomads in this community were the Zebra Finch and Crimson Chat and in autumn 1993 the Zebra Finch was the most abundant bird in this community. Nomads comprised less than 1% of birds in the remaining two communities, again the Zebra Finch and Crimson Chat were most common.

### 4.4.3 **Relationships between habitat variables and general bird distribution patterns**

An ordination of census plots based on bird species composition was performed in three dimensions. The stress for a 2-D ordination was 0.224 and for the 3-D solution was 0.147. Further increases in dimensionality gave only modest decreases in stress and increased the difficulty of interpreting results. The PCC and Monte Carlo studies indicated that a complex of environmental variables, both floristic and physiognomic, were significantly related to the ordination (Table 4.5). Overall patterns in the creekline avifauna were strongly correlated with the density of eucalypts, the distance from Peery Lake, and the width and height of creekline vegetation. Many of the significant habitat variables were themselves correlated. Five habitat variables, total eucalypt density, density of *Maireana pyramidata*, density of dead trees, distance from Peery Lake and herbage cover, were significantly related to the ordination, but were not correlated with each other. A plot of the directions of the PCC correlations of these habitat variables with the ordination (Figure 4.5) shows that there are several significant

Figure 4.3. **Patterns in total bird density in census plots in each bird community.**
Transects whose sign confidence intervals do not overlap are significantly different at roughly the 5% level (Minitab 1989).

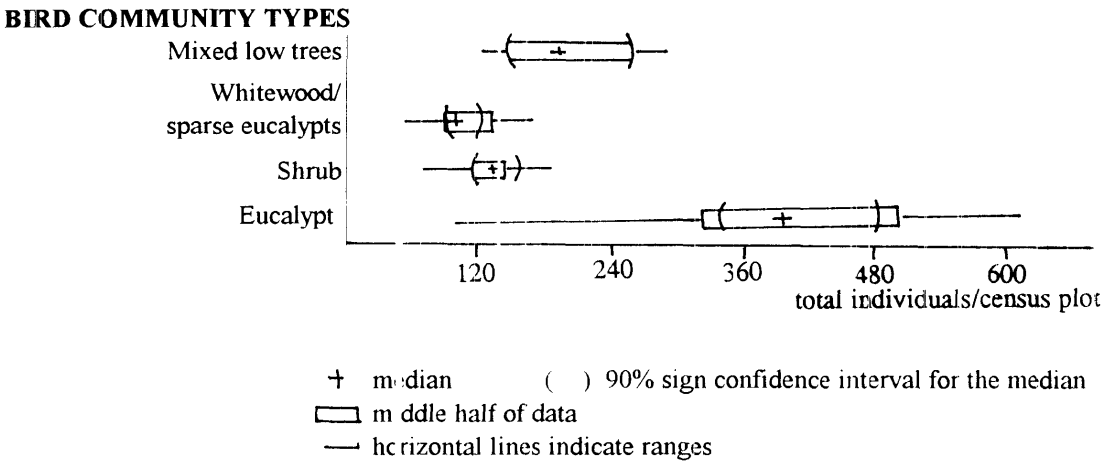



Figure 4.4. **Patterns in species richness in census plots in each bird community.**
Transects whose sign confidence intervals do not overlap are significantly different at roughly the 5% level (Minitab 1989).

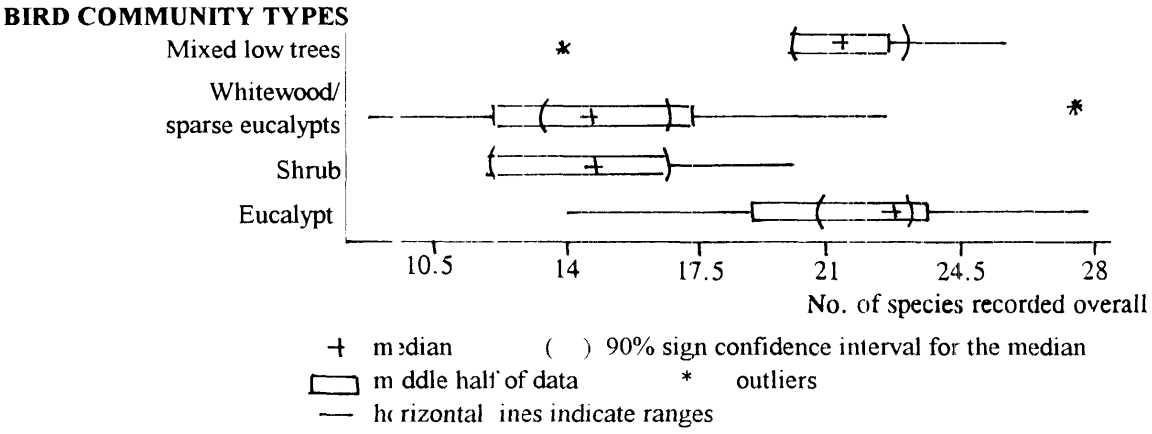


Table 4.4. **Relative composition of creekline bird community types.** Figures in tables indicate percentage occurrence of residents, nomads and migrants in terms of a) total individuals and b) total species recorded in each community type.

a) Individuals

| | Bird community type | | | |
|---|---|---|---|---|
| | Mixed low trees | Whitewood/ sparse eucalypts | Shrub | Eucalypt |
| Residents | 93 | 99 | 99 | 89 |
| Nomads | 6 | <1 | <1 | 10 |
| Migrants | 1 | 1 | 1 | |

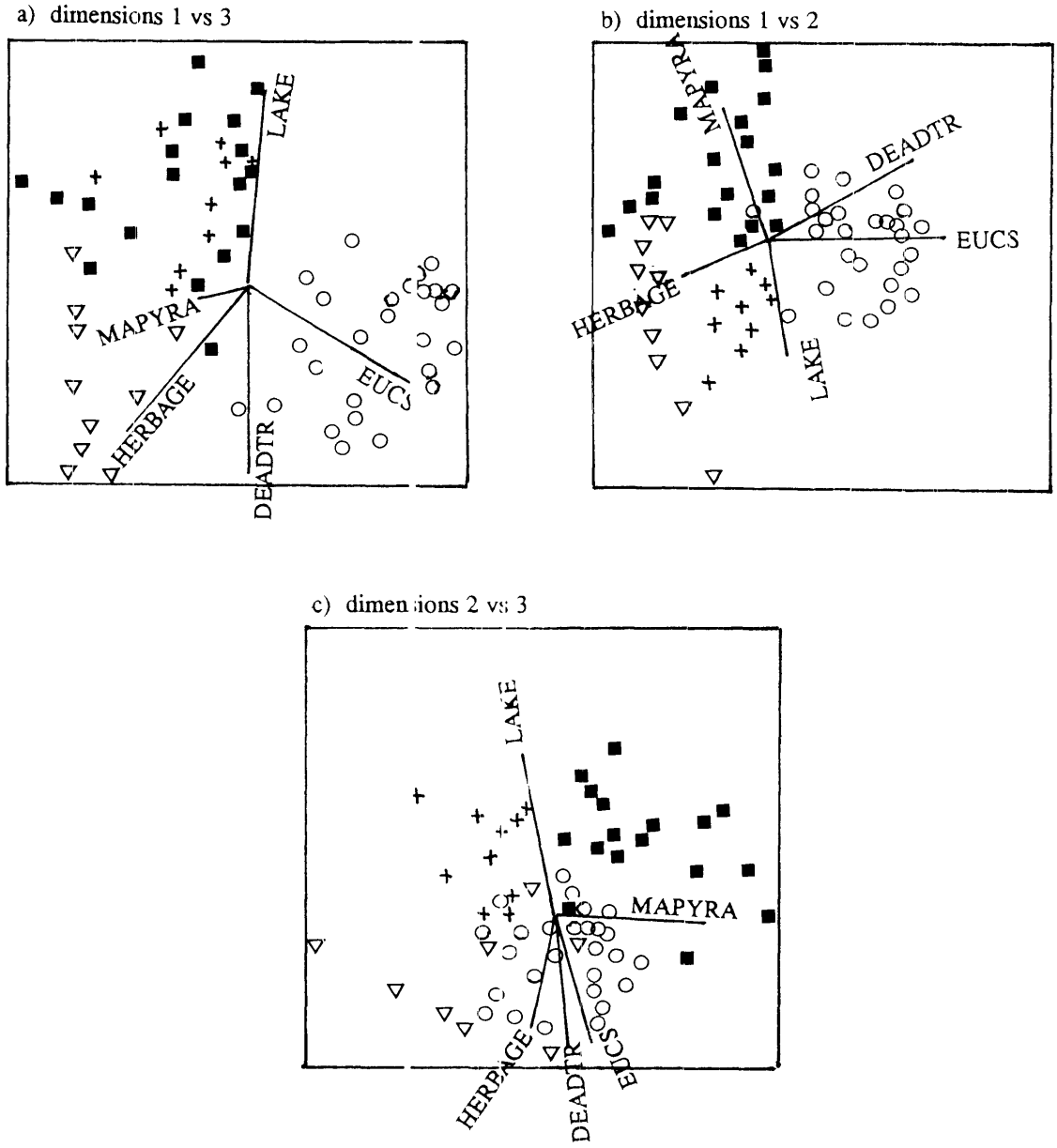
b) Species

| | Bird community type | | | |
|---|---|---|---|---|
| | Mixed low trees | Whitewood/ sparse eucalypts | Shrub | Eucalypt |
| Residents | 68 | 71 | 75 | 69 |
| Nomads | 19 | 10 | 17 | 21 |
| Migrants | 14 | 12 | 8 | 10 |

Table 4.5. **Habitat variables found to be significantly correlated ($p<0.01$) with the ordination of the census plots based on the bird species data (Figure 4.5).** The correlation coefficients were derived from a Principal Axis Correlation (PCC) analysis and their significance was tested with a Monte Carlo simulation. Variables that are significantly correlated with other variables higher in the table are shown in parentheses (Spearman Rank Correlation coefficient, $p < 0.05$, two-tailed).

| Habitat Variable | PCC correlation coefficient | Most significant correlation with a variable higher in the table |
|---|---|---|
| Eucalypt density | 0.681 | |
| Lake distance | 0.677 | |
| (Width creekline vegetation) | 0.671 | eucalypt density |
| (Height vegetation) | 0.662 | eucalypt density |
| Herbage cover | 0.621 | |
| (Adjacent shrub density) | 0.519 | eucalypt density |
| (Live tree density) | 0.488 | eucalypt density |
| Dead tree density | 0.480 | |
| (*Grevillea striata* density) | 0.466 | eucalypt density |
| (*Acacia victoriae* density) | 0.466 | width creekline vegetation |
| (Total tree density) | 0.460 | live tree density |
| *Maireana pyramidata* density | 0.454 | |
| (Ground litter cover) | 0.452 | lake distance |
| (*Eucalyptus camaldulensis* density) | 0.436 | eucalypt density |
| (*Senna* spp. density) | 0.432 | eucalypt density |
| (Availability of drinking water) | 0.431 | eucalypt density |
| (*Acacia tetragonophylla* density) | 0.426 | eucalypt density |
| (Ground stone cover) | 0.422 | eucalypt density |
| (Total tree and shrub density) | 0.416 | herbage |
| (Total shrub density) | 0.407 | total tree and shrub density |
| (*Scaevola spinescens* density) | 0.405 | lake distance |
| (*Muehlenbeckia florulenta* density) | 0.403 | eucalypt density |
| (*Eucalyptus largiflorens* density) | 0.398 | eucalypt density |
| (*Myoporum montanum* density) | 0.395 | total tree and shrub density |
| (Adjacent tree density) | 0.387 | live tree density |

Figure 4.5. **Three-dimensional ordination of 65 census plots based on the composition of the avifauna in spring and winter 1991-93**. The figure illustrates dimensions a) 1 vs 3, b) 1 vs 2, c) 2 vs 3. The direction of PCO correlations of habitat variables with the ordination which are significant at $p < 0.01$ (Monte Carlo simulation) and which are not significantly correlated with other habitat variables (Spearman rank correlation coefficient, $p < 0.05$, two-tailed) are shown in each dimension Habitat variables are **EUCS** total eucalypt density, **MAPYRA** density *Maireana pyramidata*, **DEADTR** density of dead trees, **LAKE** distance from Peery Lake, **HERBAGE** herbage cover. The bird community types identified in the UPGMA analysis are indicated as ○ Eucalypt bird community, ▽ Shrub bird community, ■ Whitewood/sparse eucalypt bird community, + Mixed low trees bird community.



gradients of habitat variation.

### 4.4.4 **Relationships between habitat variables and individual bird species**

The relationships of total abundance, species richness and the abundance of 23 individual species, for which at least 100 individuals were counted overall, to habitat variables were examined. Regression analyses showed significant relations, either positive or negative, of individual species with from zero and up to 14 habitat variables each (Table 4.6). Many, but not all, of the multiple relations occurred because the habitat variables themselves were correlated. No significant relations were found between only one species, the Crimson Chat, and habitat variables.

Birds were most abundant in creeklines with the highest densities of tall trees, especially eucalypts, and broad corridors of riparian habitat. Species richness was greatest in creeklines with the highest densities of tall trees, especially eucalypts. There were marked differences between species in the relative importance of habitat attributes and the proportion of the variability in bird numbers that could be accounted for by variability in habitat attributes.

A number of species, both resident and nomadic, were not strongly associated with (<20% of the variability in the numbers of the bird was accounted for by variation of any habitat variable) any habitat attributes. Such species occurred widely in creeklines and included the ground-feeding Blue Bonnet, Crested Pigeon, Crimson Chat, Zebra Finch, Apostlebird and Willie Wagtail, as well as the Mallee Ringneck and Yellow-throated Miner which fed in vegetation. The Blue Bonnet, Crested Pigeon and Crimson Chat fed mainly in run-off habitats. The Crimson Chat occurred only sporadically in creeklines, while the Blue Bonnet and Crested Pigeon used creeklines for shelter and nesting. The Zebra Finch, Apostlebird and Willie Wagtail fed and nested widely in creeklines and in run-off habitats. The Mallee Ringneck and Yellow-throated Miner made opportunistic use of the flowers, fruit and foliage of a large range of plant species in creeklines (Chapter 5).

In contrast to these widespread birds were species strongly associated with particular habitat variables. Occurrences of these birds in creeklines were more predictable.

**Table 4.6. Relationships between total species, total numbers and numbers of individual species, and habitat variables. The size (**p<0.01, ***p<0.001) and sign of** significant (modified Bonferonni adjusted significance levels) relationships are indicated. The percentages are the amount of variability in bird numbers accounted for by each habitat variable. Abbreviations for habitat variables are as in Table 4.1.

| BIRD SPECIES GROUPS | HABITAT VARIABLES: | ACSTEN | ACTETR | ACVICT | ADSHRUBS | ADTREES | ALLSHRUBS | ALLTE/SH | ALLTREES | ATHEMI | DEADTR/SH | DEADSH | EUCAMA | EULARG | EUCS | GRTSRI | HEIGHT | HERBAGE | LAKE | LITTER | LIVETR | MAPYRA | MUFLOR | MYMONT | SALANC | SCSPIN | SENNAS | STONES | WATER | WIDTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total species | | | | | | | | ** (+) 14% | | | | | | **(+) 15% | | ***(+) 16% | | | | ***(+) 21% | | | | | | | | | |
| | Total no. individuals | | | | | | | | ***(+) 15% | | | | | | ***(+) 33% | | ***(+) 29% | | | | ***(+) 20% | | | | | | | | *(+) 14% | ***(+) 16% |
| Group 1 | Singing Honeyeater | | ***(+) 19% | | ***(+) 34% | | | | | ***(+) 20% | | | | | **(-) 15% | ***(+) 20% | | | ***(+) 29% | | | | | | | | ***(+) 18% | | | |
| Group 1 | Chestnut-crowned Babbler | | | | ***(+) 30% | | | | | | | | | | ***(-) 17% | **(+) 14% | | | ***(+) 32% | | | | | | ***(+) 17% | ***(+) 15% | ***(+) 25% | | | |
| Group 1 | Zebra Finch | | | | | | | | | | | | | | | | | | **(+) 13% | | | | | | | | | | | |
| Group 2 | White-winged Fairy-wren | **(-) 11% | | | | | | | | | | | | | | | **(-) 13% | | | | | | ***(+) 42% | | | | | | | ***(+) 42% |
| Group 2 | Variegated Fairy-wren | | | | | | | | | | | | | | | | | ***(+) 28% | | | **(-) 14% | | ***(+) 16% | | | | | | | ***(-) 32% |
| Group 2 | Southern Whiteface | | | ***(+) 31% | | **(-) 12% | | | | | | | | | ***(-) 26% | | **(-) 13% | | | | | | | | | | | | ***(-) 16% | ***(-) 38% |
| Group 3 | Rufous Songlark | | | | | | | | ***(+) 21% | | | | | **(+) 16% | ***(+) 28% | | | | | | ***(+) 21% | | | | | | | | ***(+) 18% | |
| Group 3 | Grey Shrike-thrush | | | | ***(+) 18% | | ***(+) 18% | ***(+) 19% | ***(+) 22% | | ***(+) 15% | **(+) 14% | ***(+) 23% | | ***(+) 58% | | ***(+) 29% | | | ***(+) 22% | ***(+) 21% | | | ***(+) 24% | | | | | | ***(+) 21% | ***(+) 34% |
| Group 3 | Rainbow Bee-eater | | | | | | | | ***(+) 19% | | | | ***(+) 17% | **(+) 13% | ***(+) 42% | | ***(+) 26% | | | | ***(+) 17% | | | | | | | | | ***(+) 18% |
| Group 3 | Brown Treecreeper | | | | **(-) 13% | | | | | | | | | | ***(+) 20% | | **(+) 10% | ***(-) 41% | | | | | | | | | | | | |
| Group 3 | Galah | | | | **(-) 12% | | | | **(+) 14% | | | | ***(+) 26% | | ***(+) 42% | | ***(+) 29% | | | | | | | | | | | | ***(+) 22% | |
| Group 3 | White-browed Woodswallow | | | | | | | | | | | | | | ***(+) 17% | | | | | ***(+) 16% | | | | | | | | | | | ***(+) 14% |
| Group 3 | Spiny-cheeked Honeyeater | | | | ***(+) 15% | | | | | | | | | | | | | ***(+) 16% | | | | | | | | | **(+) 15% | | | |
| Group 3 | Willie Wagtail | | | | | | | | | | | | | | | | | | | | **(+) 12% | ***(-) 16% | | | | | | | | |
| Group 3 | Yellow-throated Miner | | | | | | | | | | | | | | | | | | | | | | **(-) 15% | | | | | | | ***(+) 17% |
| Group 3 | Apostlebird | | | | | | | | | | | | | | | | | ***(-) 17% | | | | | | | | | | | | |
| Group 3 | Mallee Ringneck | | | | | | | | | | | | | | | | | ***(-) 17% | **(+) 10% | | | | | | | | | **(+) 11% | | |
| Group 3 | Blue Bonnet | | | | | | **(-) 11% | **(-) 10% | | | | | | | | | | | | | | | | | | | | | | |
| Group 3 | Crested Pigeon | | | | | | | | | | | | | *(-) 9% | | | | | | | | | | | | | | | | |
| Group 3 | White-plumed Honeyeater | | | | | | **(-) 14% | **(+) 15% | ***(+) 19% | | | | | **(+) 14% | ***(+) 39% | **(-) 14% | ***(+) 26% | | ***(-) 19% | ***(+) 18% | **(+) 15% | | | ***(+) 15% | | | | | | ***(+) 19% | ***(+) 22% |
| Group 3 | Tree Martin | | | | **(-) 12% | | | | | | | | **(+) 14% | | ***(+) 29% | | ***(+) 21% | | | | **(+) 14% | | | | | | | | **(+) 12% | |
| Group 3 | Budgerigar | | | | **(-) 14% | | | | | | | | | | ***(+) 23% | | **(+) 14% | ***(-) 27% | | | | | | | | | | | | |

The Grey-shrike Thrush, Galah, Rainbow Bee-eater and White-plumed Honeyeater, for example, were closely associated with eucalypts. The White-winged Fairy-wren rarely ventured away from dense thickets of Lignum, and the Southern Whiteface concentrated in narrow sections of creekline dominated by Prickly Wattle. The Grey-shrike Thrush and White-plumed Honeyeater fed and nested mainly in eucalypts. The Galah fed on the open plains but nested in creeklines where usually only eucalypts provided hollows of sufficient size. The Rainbow Bee-eater sought exposed perches in tall eucalypts between aerial feeding bouts. The White-winged Fairy-wren fed mainly in Lignum thickets or on the ground nearby. Lignum was also preferred for nesting and shelter. The ground-feeding Southern Whiteface often sheltered in the dense foliage of Prickly Wattle.

A summary of the varied creekline habitat preferences of species in the analysis, based on associations between species and habitat variables, and interrelationships between habitat variables, is given in Table 4.7.

The habitat variables most strongly related to overall patterns in bird distribution, including total eucalypt density, distance from Peery Lake, width and height of creekline vegetation (Table 4.5), were not necessarily the most important determinants of individual species distributions. The most important overall habitat variable, eucalypt density, accounted for most variability in numbers of the two most abundant species in creeklines, the White-plumed Honeyeater and Tree Martin, and also the Rufous Songlark, Grey-shrike Thrush, Rainbow Bee-eater, Galah, White-browed Woodswallow, but showed no relationship to variability in a number of species not dependent on eucalypts, including the Zebra Finch, White-winged and Variegated Fairy-wrens and Spiny-cheeked Honeyeater. The second most influential variable overall, distance from Peery Lake, was significantly related only to the distributions of the Singing Honeyeater, Chestnut-crowned Babbler, Zebra Finch, Mallee Ringneck and White-plumed Honeyeater.

Within census plots, different bird species were associated with different plant species (Table 4.8). Roughly half the sightings made in vegetation for the Variegated and White-winged Fairy-wrens were in Lignum, for the Brown Treecreeper in Black Box, and for the Budgerigar, Grey-shrike Thrush, Tree Martin and White-plumed Honeyeater in River Red Gum. When in vegetation, Willie Wagtails were most frequently sighted in River Cooba,

Table 4.7. **Summary of habitat preferences of more common birds in creeklines, based on results presented in Table 4.5 and correlations (Spearman Rank) between habitat variables.**

| | FEATURES OF PREFERRED HABITAT WITHIN CREEKLINES |
|---|---|
| **APOSTLEBIRD** | Sparse ground layer vegetation |
| **BLUE BONNET** | Sparse shrubs |
| **BROWN TREECREEPER** | Tall eucalypts with sparse ground layer vegetation |
| **BUDGERIGAR** | Wide strips of creekline habitat with tall dense eucalypts, especially *Eucalyptus camaldulensis* , and drinking water |
| **CHESTNUT-CROWNED BABBLER** | Upper reaches of creeks where adjacent run-off areas support dense shrubs. Eucalypts are absent but shrubs such as Sennas, *Scaevola spinescens* and *Acacia tetragonophylla* , and low trees such as *Santalum lanceolatum, Grevillea striata, Atalaya hemiglauca* and *Acacia aneura* are common |
| **CRESTED PIGEON** | Narrow, low strips of creekline vegetation where *Acacia tetragonophylla* is relatively abundant |
| **GALAH** | Wide strips of tall eucalypts, both living and dead, especially *Eucalyptus camaldulensis* , with drinking water. |
| **GREY-SHRIKE THRUSH** | Wide strips of tall ,dense eucalypts, especially *Eucalyptus camaldulensis*, with dense shrubs, such as *Myoporum montanum* , and dense ground litter. |
| **MALLEE RINGNECK** | Stony areas with little ground layer vegetation in upper reaches of creeks |
| **RAINBOW BEE-EATER** | Tall, wide strips of dense eucalypts with drinking water |
| **RUFOUS SONGLARK** | Dense tall trees, especially eucalypts, with drinking water |
| **SINGING HONEYEATER** | Upper reaches of creeks supporting non-eucalypt trees, such as *Atalaya hemiglauca, Grevillea striata, Santalum lanceolatum* and shrubs, such as *Acacia tetragonophylla* , Sennas and *Scaevola spinescens* , and adjacent run-off areas supporting dense shrubs |
| **SOUTHERN WHITEFACE** | Narrow, treeless and waterless sections of creekline with plentiful *Acacia victoriae* |
| **SPINY-CHEEKED HONEYEATER** | Dense shrubs, both living and dead, especially Sennas, *Myoporum montanum* and *Scaevola spinescens* , ground layer with good cover of vegetation but sparse litter. |
| **TREE MARTIN** | High densities of tall eucalypts, especially *Eucalyptus camaldulensis* , and available drinking water |
| **VARIEGATED FAIRY-WREN** | Narrow, treeless strips of creekline habitat with dense *Muehlenbeckia florulenta* and dense ground layer vegetation |
| **WHITE-BROWED WOODSWALLOW** | Tall, wide creekline habitat with dense eucalypts and ground layer with dense litter but sparse vegetative cover |
| **WHITE-PLUMED HONEYEATER** | Tall, wide strips of dense eucalypts, *Myoporum montanum* and *Acacia stenophylla* in the lower reaches of creeks where drinking water is available and ground litter is dense |
| **WHITE-WINGED FAIRY-WREN** | Low, narrow strips of creekline habitat with thickets of *Muehlenbeckia florulenta* interspersed with *Acacia stenophylla* |
| **WILLIE WAGTAIL** | Dense tall trees, especially eucalypts, with available drinking water |
| **YELLOW-THROATED MINER** | Wider sections of creekline habitat |
| **ZEBRA FINCH** | Narrow strips of upper creekline habitat where sennas, *Acacia aneura* , *Santalum lanceolatum* and *Scaevola spinescens* are relatively common but eucalypts are absent and adjacent run-off areas support dense shrubs |

Table 4.8. **Relative use of plant species by individual bird species**. Figures in table are percentages. For each bird, the two highest percentages are bordered, highlighting differences between bird species. Only birds for which at least 100 observations were made in vegetation are included. Observations were made during censuses in creekline and run-off plots in spring and winter 1991-93 and also spring 1990 and summer 1994.

| | Apostlebird | Blue Bonnet | Brown Treecreeper | Budgerigar | Chestnut-crowned Babbler | Crested Pigeon | Galah | Grey-shrike Thrush | Mallee Ringneck | Rainbow Bee-eater | Rufous Songlark | Singing Honeyeater | Southern Whiteface | Spiny-cheeked Honeyeater | Tree Martin | Variegated Fairy-wren | White-browed Woodswallow | White-plumed Honeyeater | White-winged Fairy-wren | Willie Wagtail | Yellow-throated Miner | Zebra Finch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No. of obs. in vegetation** | 1003 | 554 | 241 | 995 | 477 | 382 | 367 | 127 | 423 | 124 | 114 | 124 | 255 | 650 | 310 | 472 | 115 | 4723 | 185 | 598 | 1656 | 455 |
| **Mulga** *Acacia aneura* | 6.8 | 8.2 | | | 10.9 | 6.3 | 0.8 | | 5.7 | | 1.8 | 4.8 | 11.8 | 4.9 | | 0.9 | | | | 3 | 5.9 | 6.8 |
| **River Cooba** *Acacia stenophylla* | 1.5 | 3.3 | 0.4 | 0.9 | 1.3 | 3.7 | | 5.5 | 2.4 | 0.8 | 2.6 | | 1.2 | 7.2 | | 5.3 | 1.7 | 5.3 | 11.4 | **19.6** | 1.6 | 2.4 |
| **Dead Finish** *Acacia tetragonophylla* | | 0.2 | | | 0.8 | 0.8 | | | 1 | | | 6.5 | 1.6 | 0.6 | | 0.4 | | | | 0.5 | 0.6 | 7.5 |
| **Prickly Wattle** *Acacia victoriae* | 2.2 | 8.7 | | | **18.2** | 1.8 | | | 1.4 | | | 6.5 | **16.1** | 8.2 | | 11 | | 0.9 | **25.4** | 3.7 | 5.5 | 9.5 |
| **Rosewood** *Alectryon oleifolius* | 0.1 | 1.4 | 0.4 | 2 | 4 | 1.1 | | | 1 | | 1.8 | 5.7 | 0.8 | 2.2 | | 0.9 | | | | 2.5 | 1 | 1.8 |
| **Whitewood** *Atalaya hemiglauca* | **31.8** | **28.3** | 8.3 | 3.1 | **21.2** | **8.4** | 11.7 | 3.9 | 12.1 | 1.6 | 8.8 | **20.2** | 8.2 | **12.5** | | 1.3 | 3.5 | 1 | | 14.4 | 20.7 | 0.9 |
| **Belah** *Casuarina cristata* | | | | | | 3.1 | | 0.8 | 0.7 | | 0.9 | | | 0.3 | | | 0.9 | 0.3 | | | 0.5 | 0.7 |
| **Dead shrubs** | 5.7 | 4.5 | 0.4 | | 9.4 | 8.9 | | | 1.4 | 6.5 | **17.5** | 1.6 | **33.7** | 3.9 | | **12.5** | 1.7 | 0.4 | 6.5 | 6 | 0.5 | **42** |
| **Dead trees** | 2.2 | **12.1** | 6.6 | 8.6 | 2.9 | **47.9** | **41.7** | 3.9 | 6.6 | **51.6** | **37.7** | | 7.5 | 3.2 | 22.6 | 2.3 | **40** | 2.5 | 1.1 | 7.2 | 3.4 | 4.4 |
| **Eurah** *Eremophila bignoniflora* | 2.1 | | | | | | | | 0.5 | | | | | 4 | | | | 0.5 | | | 1.8 | |
| **Harlequin Eremophila** *Eremophila duttonnii* | 0.8 | 2 | | | 6.7 | 0.3 | | | 2.6 | | | **33.1** | 2 | **20.6** | | 3 | | 0.4 | | 0.5 | 3.4 | 2.6 |
| **River Red Gum** *Eucalyptus camaldulensis* | 16 | 9.2 | **14.9** | **55.6** | 12.2 | 7.6 | **35.4** | **50.4** | **35.9** | 10.5 | 7 | | 2.4 | 7 | **46.8** | 3 | 12.2 | **46.2** | 1.1 | **18.6** | **24.9** | 4.2 |
| **Blackbox** *Eucalyptus largiflorens* | **25.4** | 11.2 | **56.4** | **21.9** | 2.3 | 5.2 | 7.6 | **33.9** | **13.7** | **25** | 11.4 | | 1.2 | 10.9 | **24.8** | | **26.1** | **39** | | 15.6 | **22.2** | |
| **Bimblebox** *Eucalyptus populnea* | 0.9 | 3.8 | 12 | 7 | | 0.8 | 2.7 | 1.6 | 1.2 | 4 | 7 | | | 0.2 | 5.5 | | 10.4 | 1.2 | | 3.7 | 0.6 | 0.2 |
| **Beefwood** *Grevillea striata* | 2.2 | 2 | | 0.4 | 3.8 | 2.1 | | | | | | 2.4 | 2.8 | 3 | 0.3 | | 3.5 | | | 1.2 | 4.2 | 2 |
| **Lignum** *Muehlenbeckia florulenta* | | 0.9 | | | 1.9 | 1.3 | | | | | | | 7.1 | 0.2 | | **43.6** | | 0.3 | **50.3** | | | **10.1** |
| **Boobialla** *Myoporum montanum* | | 2 | | | 3.1 | | | | 11.1 | | 1.8 | 1.6 | 2.4 | 8 | | 7.4 | | 1.6 | 2.7 | 1.3 | 0.4 | 2.2 |
| **Butterbush** *Pittosporum phylliraeoides* | | | | | | 0.5 | | | 1 | | | 6.5 | | 1.5 | | | | | | 0.8 | 1.6 | 1.3 |
| **Santalum** *Santalum lanceolatum* | 0.1 | | | | | 0.3 | | | 0.2 | | | 4.8 | | 1.2 | | | | 0.1 | | 0.2 | 0.7 | |
| **Cassia** *Senna artemisioides* | 3 | 0.4 | | | 0.6 | | | | | | 0.9 | 4.8 | 0.8 | 0.5 | | | | | | 0.2 | | |

Apostlebirds, Blue Bonnets and Chestnut-crowned Babblers in Whitewood, Southern Whiteface and Zebra Finch in dead shrubs, and Spiny-cheeked and Singing Honeyeaters in Harlequin Eremophila. Dead trees comprised less than 20% of trees in census plots (Chapter 3) but were preferentially used by the Rainbow Bee-eater (52% of all records in vegetation), Crested Pigeon (48%), Galah (42%), White browed Woodswallow (40%) and Rufous Songlark (38%). Rainbow Bee-eaters and White-browed Woodswallows searched for food (flying insects) and Rufous Songlarks sang territorially from perches in dead trees, while Galahs nested in their hollows. Possibly dead trees offered better vantage points from which to seek prey and sight predators and intruders, and had more large hollows than living trees.

## 4.5 DISCUSSION

In this study of a local area, differences in the composition of the avifauna within creeklines enabled four creekline bird community types to be distinguished. These were the 'eucalypt', 'shrub', 'Whitewood/sparse eucalypts', and 'mixed low tree' bird communities. The bird community of the lower reaches of major creeks - the eucalypt community, clearly contained the densest populations of birds. In terms of species richness, it was matched by the bird community of creekline dominated by mixed, low, non-eucalypt trees. In the Whitewood/sparse eucalypts and shrub bird communities bird densities were only about one third of those recorded in the eucalypt community. Species richness was similar in the Whitewood/sparse eucalypts and shrub communities and only about half of that recorded in the other two communities. Most birds occurred, at least to some extent, in all communities. However, the relatively mesic eucalypt community included a number of species not found in other communities. About half of the species of birds found in the other three drier communities were largely restricted to them. Birds such as the White-winged Fairy-wren, Yellow-rumped Thornbill, Singing Honeyeater and White-fronted Honeyeater, were never recorded in the lower reaches of major creeks.

The eucalypt community at Peery is dominated by two species, the White-plumed Honeyeater (38% of all birds and 45% of residents counted) and the Tree Martin (16% and 20% respectively). Eucalypt forests and woodlands in more mesic parts of Australia typically

include a few 'most common' species (Recher 1985), but are not dominated to the same extent by only one or two species. Loyn (1985) compared the relative populations of birds in a range of Victorian eucalypt forests (Loyn 1985). He found that the eucalypt community containing the single most numerous species was River Red Gum forest. In Victorian River Red Gum forest Loyn (1985) found that the White-plumed Honeyeater comprised 25% of all birds recorded.

Bird-habitat relationships in creeklines were identified at the community level and at the individual species level. The single most important factor determining (either positively or negatively) overall patterns in the creekline avifauna was eucalypt density. Distance from Peery Lake was next most important and was not correlated with eucalypt density. This factor may mainly reflect the occurrence of shrubland habitats adjacent to the creeklines away from the Lake. The Chestnut-crowned Babbler, Singing Honeyeater and Spiny-cheeked Honeyeater were most numerous in creekline with relatively dense shrubs in adjacent run-off areas away from the Lake. In such situations these birds frequented both the creekline and run-off habitat and both habitats were important to them.

The four bird community types distinguished in the study represent a gradient from wetter, eucalypt-fringed creeklines to drier, non-eucalypt creeklines surrounded by shrubland. A number of broader scale studies in more mesic regions of eastern Australia, e.g. Kikkawa 1968, Loyn 1985, Shields *et al.* 1985, have also documented changes in the composition of avifauna along mesic-xeric gradients. At Peery, there was a gradation between and within community types along this mesic-xeric gradient (as illustrated by the ordination of census plots in Figure 4.5) reflecting the continuity of habitat variation. Cluster analyses were used to group the bird species with similar distributions. In each bird species group there is heterogeneity. The pattern is not a neat one of sets of bird species restricted to specific bird communities and to specific portions of the overall habitat gradient. As might be expected, the pattern is more complex than this. Nevertheless, it is clear that there are major differences between the bird community associated with the eucalypt vegetation of the more mesic creeklines, and the bird communities of the more xeric, non-eucalypt creekline vegetation.

Apart from the gradient in eucalypt density, gradients reflecting the density of non-eucalypt trees, such as Beefwood, and shrubs, including Lignum, Dead Finish, Cassia and

Black Bluebush, also influenced avifaunal patterns in creeklines. The PCC analysis indicated that relations between habitat gradients and overall avifaunal patterns were complex. The high number of significant and different habitat gradients suggested varied responses on the part of individual species to habitat variability. Factors important in determining overall distribution patterns were not necessarily the most influential at the level of the individual species. This also suggested that individual species were responding to habitat variability in a species-specific manner.

Observations of plant use often supported the results of the regression analyses. Additional bird/habitat relationships not evident from plot analyses were also revealed by plant use observations. Correlations between dead trees and birds were generally not picked up in the regression analyses. Apart from a small area of flood-killed trees in the lower reaches of Box Creek, dead trees were evenly spread throughout all but the treeless sections of creekline. A number of species, including the Crested Pigeon, Galah, White-browed Woodswallow and Rufous Songlark, used them in preference to live trees to perch or nest in, if they were available. For these birds one dead tree probably sufficed as well as a cluster of dead trees and the presence or absence of dead trees, rather than their density as was measured, may have been a better measure of their importance. In this instance, the habitat feature correlated with bird numbers may not have been identified in regression analyses because the scale of measurement did not correspond with the scale at which birds used the particular habitat feature.

Over half of the observations of Brown Treecreepers were made in Black Box, although it comprised only 13% of trees in census plots. The association was not apparent in the regression analyses as only some, not all, sections of creekline with dense Black Box supported high numbers of Brown Treecreepers. Presumably, for Brown Treecreepers, suitable habitat included Black Box in addition to other habitat features. In this study, habitat features were looked at independently and their importance was not established independently of other attributes. Birds, such as the Brown Treecreeper, may be responding to a complex of attributes. However, single attributes identified as strongly related to the distribution of a species are likely to be critical habitat.

The determination of correlations between habitat variables and bird numbers does

not prove that one is the cause of the other. Further investigations, including foraging (Chapter 5), nesting (Chapter 6) and drinking (Chapter 7) studies, are required to substantiate the importance of habitat features.

The gradations and overlaps in the distributions of species along the creekline gradient may be interpreted, as Kikkawa (1982) and others have concluded, as a consequence of species being distributed independently of each other. Along creeklines, changes in the composition of the avifauna reflect the differing resource requirements of individual species coupled with differing availabilities of resources. Birds with similar distributions may be responding to similar resources or to differing resources which are, to varying extents, similarly distributed. Widespread species are either generalists, or the specific resources they concentrate on are widely distributed. The distributions of nomadic species, which are only present intermittently, span the arid-mesic spectrum and are determined by their individual habitat requirements.

Such an interpretation of patterns suggests that the community is not tightly structured. It is in keeping with the conclusions of other studies in grassland and shrubsteppe (Wiens & Rotenberry 1981), deserts (Rosenberg *et al.* 1982, Rice *et al.* 1983), temperate deciduous forest (Holmes & Sherry 1986), rainforest (Kikkawa 1982) and forests of south-eastern Australia (Recher *et al.* 1991), that birds respond individually to different habitat attributes. It suggests that communities are not integrated entities of interacting species (e.g. MacArthur 1972, Diamond 1978), but are collections of species arrayed along environmental gradients more or less independently, each according to its own ecological requirements (e.g. Gleason 1917, Curtis 1959, Wiens & Rotenberry 1981).

There did, however, appear to be some positive associations among species. When investigating the foraging behaviour of birds at the study site (Chapter 5), I noted the size and species composition of feeding flocks. In winter, mixed-species flocks (in which birds fed close together and moved in the same general direction) of small insectivores were frequently noted. These flocks ranged in size from several up to 20 birds. The species composition of flocks was not constant and they variously included all birds, apart from the Australian Magpie, placed in Group 2 by the multivariate analysis, that is, the White-winged and Variegated Fairy-wrens, Yellow-rumped and Chestnut-rumped Thornbills, Southern Whiteface, Red-capped Robin and

Grey Fantail. The existence of such mixed-species flocks in more mesic environments is well known (e.g. Bell 1980, 1982, 1986, Hermes 1981, Diamond 1987). It has been hypothesised that members of these flocks travel together to find food to increase foraging efficiency (Krebs 1973, Morse 1978), to increase vigilance against predators (Lack 1968, Goss-Custard 1970) or because they are naturally gregarious (Wing 1941). The Willie Wagtail (Group 3) sometimes joined these flocks. It also tagged groups of Apostlebirds and Yellow-throated Miners foraging on the ground, presumably taking advantage of the insects disturbed by the larger birds. Mixed flocks of large granivorous birds were also noted feeding on the ground in run-off areas adjacent to creeklines. These variously included Galah, Little Corella, Blue Bonnet, Pink Cockatoo, Mulga Parrot and Crested Pigeon. These birds may have been feeding at a concentration of seed or, like the mixed-species flocks of smaller birds, it may have been advantageous for them to feed together. Low numbers of Masked Woodswallow were recorded at the site and these were only seen feeding within flocks of White-browed Woodswallow. It was probably beneficial for these aerial feeders to feed in a larger mixed flock.

If a community is not tightly structured, then the absence of a particular species is equated with a lack of suitable resources. Thus, it could be inferred that the small birds of the shrub layer, such as the White-winged and Variegated Wrens, Yellow-rumped and Chestnut-rumped Thornbills, Southern White-face, Red-capped Robin and Grey Fantail, are absent from the lower reaches of major creeklines because they lack suitable habitat. However, these most mesic sections of creekline harbour very high concentrations of White-plumed Honeyeaters which are particularly aggressive. In more mesic environments, aggressive honeyeaters such as the Noisy Miner *Manorina melanocephala* (Dow 1977), Bell Miner *M. melanophrys* (Loyn *et al.* 1983) and Fuscous Honeyeater *Lichenostomus fuscus* and White-naped Honeyeater *Melithreptus lunatus* (Davis & Recher 1993) can exclude other species from their territories. The aggressive behaviour of the White-plumed Honeyeater is investigated further in Chapter 8.

At the local level of this study, I suggest that the distribution of birds in creeklines is primarily a reflection of their species-specific habitat preferences. However, species are not entirely independent of one another. At times it is probably advantageous for birds such as the small insectivores of mixed-species foraging flocks to band and move together. Factors, such as the aggression of White-plumed Honeyeaters, modify the distributions of species.

The distributions of nomadic species, which are present only intermittently, span the arid-mesic spectrum. There were no obvious differences between nomadic and resident species in terms of their distribution along the mesic-xeric spectrum. The distributions of individual nomads were probably determined primarily by their individual habitat requirements. The Budgerigar, for example, occurred mainly at the most mesic end of the creekline spectrum where eucalypts provided nest hollows. The Zebra Finch and Rufous Songlark occurred more widely as the resources they used in creeklines, seeding grasses for the Zebra Finch and dense ground cover for the Rufous Songlark, were more widely distributed when present.