

ROOSTING BEHAVIOUR OF THE RAINBOW BEE-EATER *Merops ornatus* IN SUBURBAN DARWIN

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The Rainbow Bee-eater *Merops ornatus* is a dry season migrant to Darwin. A study of their roosting habits in suburban Darwin during the dry season over three successive years yielded a total of 13 communal roosts, most of which were located by following birds just prior to dusk. The approximate number of birds in each roost and the area over which these birds travelled to forage was estimated and from this an estimate of a density of 0.22 birds ha⁻¹ in the northern suburbs of Darwin was extrapolated. The location of roosts was generally geographically stable both within and between seasons. Rainbow Bee-eaters were observed sharing a roost tree with six other species of bird. The gradual decline of one roost from 320 to no birds, as they migrated south at the end of the season, provided some evidence of group cohesion of foraging and migrating birds.

INTRODUCTION

Large numbers of Rainbow Bee-eaters *Merops ornatus* migrate to the Darwin region from southern Australia, arriving in March and departing in August (Thompson 1984). Some of these birds transit through the Darwin region on their way to the Lesser Sunda Islands of Indonesia (Higgins 1999). The majority of Rainbow Bee-eaters in Darwin at this time are migrants and their migratory habits dictate the size of the population in Darwin. A small resident population is present year round which begins breeding in August or September, shortly after the departure of the migrants (Thompson 1984).

While breeding, Rainbow Bee-eaters tend to roost in pairs or in their nest (Fry 1984). Non-breeding birds, however, roost in trees in colonies of 30 or more birds (Warham 1957; Kloot and Easton 1983; Garnett 1985; Saffer and Calver 1997). Birds travel to the roost from their foraging grounds between 15 to 60 minutes prior to sunset, eventually settle down before dark and leave at dawn the following morning (Lord 1933; Warham 1957; Kloot and Easton 1983). Both Warham (1957) and Bell (1970, 1982) noted that roosting birds exhibit some degree of site fidelity over a number of weeks and even in subsequent years. However, very little is known of the density of roosts in an area or the distance that birds fly from the roost to forage, although Bell (1969) observed birds travelling to a foraging site 3 kilometres from their roost.

This study arose from a parallel study designed to assess the usefulness of examining regurgitated Rainbow Bee-eater pellets collected underneath roosts as a monitoring tool for the presence of honey bees. To facilitate that study, a reliable means of locating roosting colonies and information about colony longevity and density were required and in the process of accumulating this data other useful observations were made about the roosting behaviour of the Rainbow Bee-eater.

METHODS AND MATERIALS

Location of roosts

Initial attempts to locate roosts in January 1999 relied on input from members of the public. Public assistance was enlisted via radio and television news interviews and advertising on the Northern Territory government website. During May-June 1999 and May-August 2000 roosts were located by following birds as they flew to their roost in the 30 minutes prior to sunset. In May-June 2001, colony sites from previous years were visited to see if the colony had re-established. Groups of three to 12 birds were seen flying at 20 metres or higher and usually in a direct line to their roost. The easiest means of detecting these flying groups was by listening for their incessant calling as they flew, following them as far as possible, then waiting for another group to fly past and following these birds. An attempt was also made to locate roosts by backtracking birds as they left the roost in the morning.

Each of Darwin's suburbs were searched for birds flying to roosts. Additionally, eucalypt and mangrove forest fringe at Lee Point (12°20.0'S, 130°53.6'E), East Point Reserve (12°24.6'S, 130°49.0'E) and Charles Darwin National Park (12°26.9'S, 130°52.5'E) were searched. Attempts to follow Bee-eaters to roosts in native forest were unsuccessful. The canopy hindered reliable observation of the direction in which birds were flying and on the occasions this could be observed at Charles Darwin Park, East Point and Lee Point, it was not possible to follow the birds because they flew into mangrove forest.

Behaviour

Two methods of locating Rainbow Bee-eaters in the 30 minutes prior to sunset were employed. The first was to wait in an open area for a group of birds to fly overhead. The second was to find a foraging bird and watch it until it left to fly to its roost. The latter method allowed the behaviour of Rainbow Bee-eaters to be observed and also provided information on where birds foraging in a specific area were roosting. Observations on group behaviour and direction of flight were also made by watching birds as they departed from the roost in the morning or as they arrived at a roost in the evening. At one roost, the time of departure, number and size of groups leaving the roost and the direction they flew were recorded over a number of days.

Size of roosts

The number of birds in each roost was estimated by counting birds as they left the roost shortly after dawn. All roosting colonies in the northern suburbs of Darwin (those marked with # in Table 1) were counted in mid to late August 2000. From these counts an estimate of

TABLE 1

The approximate size, location, distance to nearest neighbouring roost and direction of departure of Rainbow Bee-eaters at 13 colonial roosting sites in suburban Darwin, 1999 to 2001.

Roost Location	Known to be active †	Distance to nearest neighbouring roost (km)	Approximate number of birds (No of counts made) ‡	Site description	Direction taken by majority of departing birds $\pm 45^\circ$
Wanguri#	Jan 1999, May–Aug 2000; Apr 2001	1.2	90	Park	NE
Karama#	May 1999, May–Aug 2000	2.5	50	School ground	—
Millner#	May–Aug 1999, May–Sep 2000; Apr–May 2001	1.5	310	Park, car parking area	ENE
Ludmilla	May–June 1999	1.2	—	Horse stables	—
Fannie Bay	June 1999; May–Aug 2000; May 2001	1.2	65 (2)	Roadside	E
Stuart Park	June 1999; May 2001	2	—	Park	—
Darwin	June 1999; May–July 2000; Apr 2001	2	31	Park	N
Moil#	May–Aug 2000; Apr 2001	1.8	130 (2)	Park	SE
Nightcliff#	May–Sep 2000; Apr 2001	1.5	160 (May 2000) 48 (Aug 2000)	School ground	E
Winnellie	May 2000	2	40* (May 2000)	Roadside	—
Leanyer#	June–Aug 2000; Apr 2001	1.2	50	School yard	SE
Narrows	June–Aug 2000; May 2001	1.8	50* (Jul 2000)	Park	—
Marrara#	June–Aug 2000; May 2001	1.8	50	Golf course	—

† Denotes months in which birds were seen at roost but does not preclude their presence at other times.

‡ Counted in mid-late August 2000 unless otherwise stated.

* Counted while in roost.

Denotes those northern suburbs used in density calculations.

the total population of Rainbow Bee-eaters in the northern suburbs of Darwin at this time was obtained by summing the total at each of these roosting colonies. When extrapolated over the area used by the birds in the northern suburbs of Darwin, the density of Rainbow Bee-eaters in this area was estimated.

Roost fidelity

The site fidelity of roosts was measured both by direct observation of birds roosting at either sunrise or sunset or by the presence of freshly regurgitated pellets underneath the roost. The abandonment of the roost at Millner due to migration was monitored by counting the number of birds leaving the roost at dawn on each day from 16 August until 22 September. Less frequent counts were also made at the Nightcliff roost over this period.

RESULTS

Location of roosts and site fidelity

Thirteen roosting colonies were located (Table 1; Fig. 1). Three of these (Wanguri, Moil and Karama) were located from reports from the public, while the other ten were located by following birds over one or two consecutive evenings. The colony at Moil moved sometime between May and August 2000 and its new location was found by backtracking birds over three consecutive mornings as they left the colony to forage. Eleven of the 13 roosts were in open areas, such as public parks and school grounds, the remaining two were on roadsides (Table 1).

All roosting colonies were in either black wattle *Acacia auriculiformis* (47%) or African mahogany *Khaya*

senegalensis (41%) trees except on two occasions when birds roosted in a tall eucalypt (Nightcliff) and a milkwood *Alstonia actinophylla* (Marrara). All roost trees were at least 8 metres tall.

In 1999, one roost was found in January and a further six were found between May and June. None of these roosts were active after the majority of Rainbow Bee-eaters migrated south in September. In 2000, 11 roosts were found between May and August and five of these were in trees within 200 metres or even in the same tree as those located in 1999. In May–June 2001, all sites which contained roosting colonies in 2000, excepting Winnellie, Karama and Wanguri, had roosting colonies in the same or nearby tree. Of the seven roosting sites detected in 1999, three had re-established in the same area for three consecutive years and one (Stuart Park) reappeared during 2001 despite not being detected in 2000. Nine of the 11 roosting sites found in 2000 re-established during 2001.

The Nightcliff roost was unique in that the tree, a 20 metres African mahogany, hosted six roosting species (Appendix 1) including a large roost of more than 200 Red-collared Lorikeets *Trichoglossus haematodus rubritorquis*. At Millner, however, a colony of Red-collared Lorikeets roosted in the same tree, an 8 metres African mahogany, as the Rainbow Bee-eaters and the following evening the Rainbow Bee-eaters moved to roost in a nearby tree.

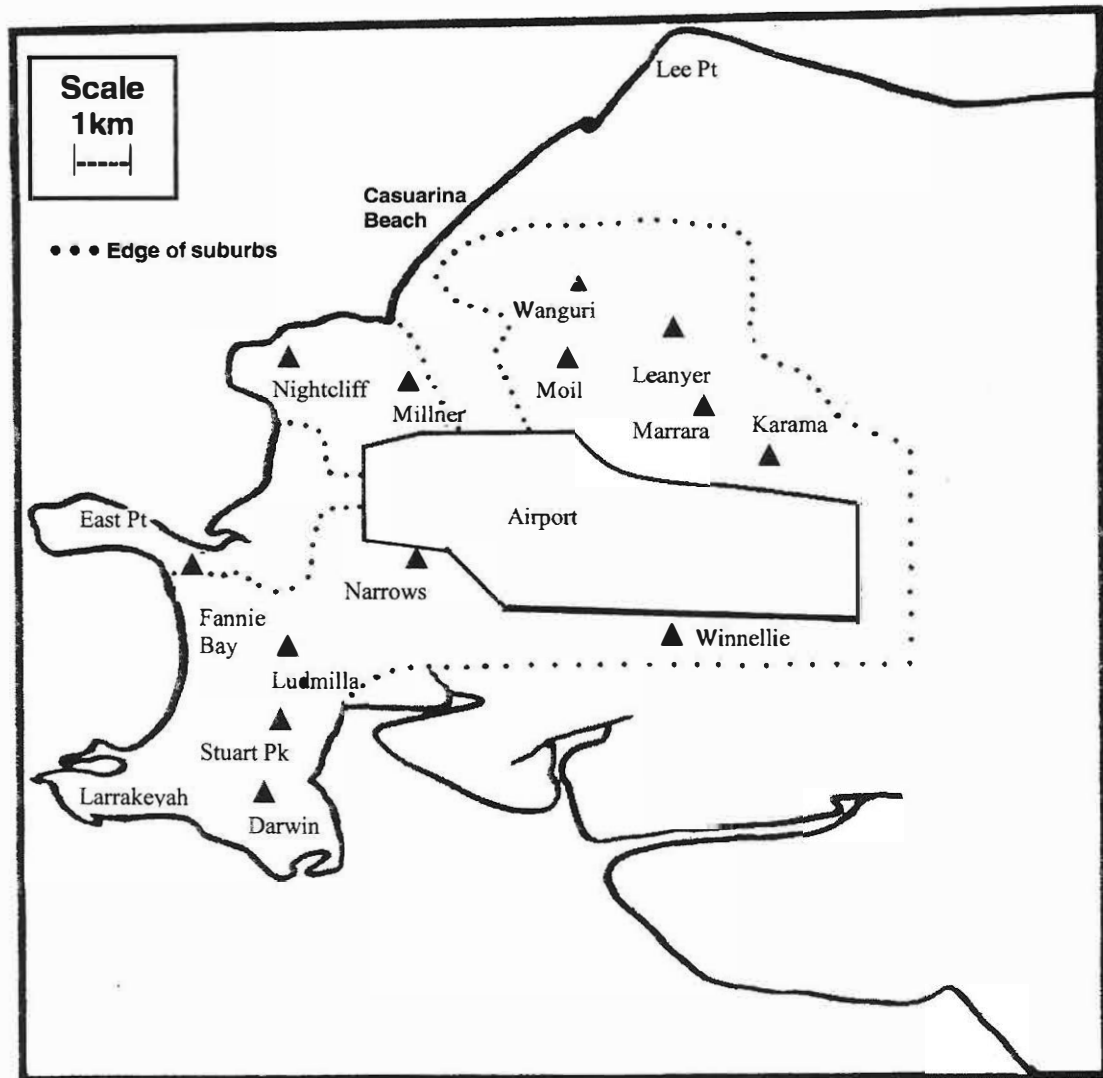


Figure 1. Location of Bee-eater roosts in Darwin 1999–2001.

Without exception, all roosts relocated at least once during this study, usually to another tree within 200 metres of the original roost, where they either remained (Millner, Leanyer, Marrara, Moil, Nightcliff) or re-established in the original tree after a few nights (all other roosts excepting Moil and Winnellie). The Moil roost relocated to a tree about 1 kilometre from the roost where it was initially detected but remained in that tree for the remainder of the study. The roost at Winnellie remained for only one night after it was found and could not be found nearby on subsequent nights. This colony gathered in an eight metres black wattle beside a road and birds were observed flying out of the tree whenever large vehicles drove past. The Darwin colony roosted in a 15 metres African mahogany adjacent to a night club which remained well lit and noisy well into the night and persisted from at least June until August 2000 and was used in all three years.

Roosting site fidelity over a number of weeks (Warham 1959; Bell 1969) and years (Bell 1982) was confirmed during this study.

Behaviour before, during and after roosting

On several occasions, a group of Rainbow Bee-eaters foraging in an area were observed to join a bird as it circled overhead calling. Once a group of three to eight birds had formed with the calling bird, the group flew directly toward the roost. This group did not always contain every Rainbow Bee-eater that was foraging in the area prior to the calling bird's arrival. At a site at Casuarina Beach, birds foraging in the same area were thrice observed forming two separate groups that flew toward two different roosts, one group departing some five to ten minutes before the other. This location was equidistant (approx 2 km) from the two roosts to which the two groups were heading (Nightcliff and Wanguri).

Once in the roost tree, birds called incessantly and flew erratically in and out of the tree until they settled for the night. The calling of birds in the roost was audible from approximately 300 metres away. Typically, groups of two to eight birds huddled together on a branch near the top of the tree, all individuals facing the same direction. These

groups of roosting birds were difficult to see and easily overlooked by a casual inspection.

On 11 and 12 August 2000 at Moil, 47 per cent and 69 per cent of birds left the roost in groups of 40 birds and congregated in a grove of small trees about 200 metres from the roost. They milled around this area for about 10 minutes, some began catching insects, then gradually left the site in small groups of three to eight birds. By contrast, at other roosts birds left the roost in groups of three to eight birds (once each at Darwin and Leanyer) or in groups of between three and 40 (Millner 18 occasions, Wanguri one occasion, Fannie Bay two occasions, Nightcliff three occasions) and seemed to fly directly to foraging grounds without congregating in a nearby grove of trees as at Moil. These groups departed the roost over a 20 minute period.

At all roosts the majority of birds departed in the same general direction although this direction differed between roosting colonies (Table 1). On one occasion at both the Moil and Leanyer colonies, a group of three and four birds respectively were seen flying toward the roosting site, from the general direction of the Millner and Wanguri roosting sites respectively, before or shortly after birds from the Moil or Leanyer roosts had begun departing.

On each morning from 25 to 30 August 2000 the majority of birds from the Millner roosting colony flew to the east or north-east but at least two groups of between 6 and 14 birds were observed flying to the west and south-west of the roosting site (Table 2). After August 30, however, no birds were seen flying either west or south-west. Reasonable numbers of birds still roosted in the tree, but these birds all flew east or north-east.

TABLE 2

Daily changes in the number of Rainbow Bee-eaters flying in a westerly direction from a colonial roosting site at Millner, Darwin.

Date	Number, size and direction of groups	Total number of birds
August 25	SW(9)*; SW (4); W (6)#; SW (6)	25
August 26	SW (14)**	14
August 29	WSW (9)*; WNW(6)#	15
August 30	SW(8)*	8
August 31	0	0

*denotes the group of 8-9 birds that forage and ultimately migrate together.
#denotes the group of 6 birds that forage and ultimately migrate together.

At the Millner roosting site, the first bird departed the roost between 10 minutes before sunrise and 10 minutes after sunrise (mean \pm se = 4.23 ± 1.36 min, $n = 13$) and the last bird departed from 7 minutes before, to 16 minutes after sunrise (mean \pm se = 2.85 ± 7.40 min, $n = 13$). There was an average of 7.38 ± 1.93 minutes (range 1 to 20 min; $n = 13$) between the departure of the first and last bird.

Rainbow Bee-eaters were amongst the last bird species to depart their roost. Thirteen species (Appendix 1) were nearly always seen or heard in the vicinity of the Millner roosting site prior to the first Rainbow Bee-eater leaving the roost.

On 9 June 1999, the birds in the roosting colony at Stuart Park ceased calling immediately after a passing White-breasted Woodswallow *Artamus leucorhynchus* gave an alarm call. Within one minute all Rainbow Bee-eaters flew from the tree *en masse* in different directions. A large raptor, probably a Barking Owl *Ninox connivens*, was then noticed flying out of a nearby tree and was mobbed by White-breasted Woodswallows and driven away from the Rainbow Bee-eater roost tree. The Rainbow Bee-eater colony split into two groups which flew off in different directions. One group settled into a tree 300 metres away and roosted there for two nights, whilst the other group flew much further away. On the third evening birds were again seen roosting in the original roost tree.

Distance between roosting sites and size of roosting colonies

The distance between neighbouring roosting colonies varied from 1.2 to 2.5 kilometres and averaged 1.67 ± 0.11 kilometres respectively ($n = 13$). Distances between colonies were generally smaller (i.e. roosts were more densely packed) if surrounded by other colonies in suburban areas than if bordering open areas or native vegetation such as the airport.

During the period 12-22 August 2000, the number of birds per roost varied from 31 to 310 and averaged 91.56 ± 29.02 ($n = 9$). The population in the northern suburbs of Darwin at this time was estimated at 728. The total number of Rainbow Bee-eaters in Darwin could not be estimated as the location of the Stuart Park, Ludmilla and Narrows roosts was not known during this period. The total area over which birds belonging to roosting colonies in the northern suburbs were seen was about 3 300 hectares providing a density of 0.221 birds per hectare.

The changes in the size of the colony at Millner during the latter part of August and September 2000 are displayed in Figure 2. The number of birds in the colony seemed to stabilize at 14 birds after 7 September. On 9 September the roost moved to a nearby tree marking the third time this colony had moved since May. The two previous roosting sites were utilized for between six and eight weeks respectively. The colony could not be found on 10 or 11 September although three birds were seen in a tree some 200 metres away shortly after dawn on these days. On 12 September the colony had returned to the roosting site used prior to 9 September but no birds were present at this roost six days later or subsequently.

No birds were seen at the Moil or Wanguri roosts on 4 and 6 September 2000 respectively. The Nightcliff roost persisted until at least 25 September 2000 although only five birds were counted on that day.

During June 2000, groups of five to ten birds were observed foraging prior to dusk at Casuarina Beach and these were seen flying towards either the Wanguri roosting site, approximately 2 kilometres ESE or the Nightcliff roosting site approximately 2 kilometres SW. None were observed to roost in the immediate vicinity. On 8 September and 2 October 2000, only two birds, a male and a female, were present in this area. This pair were observed just prior to dusk and on 2 October they roosted together in a black wattle close to where they were foraging without being joined by other birds.

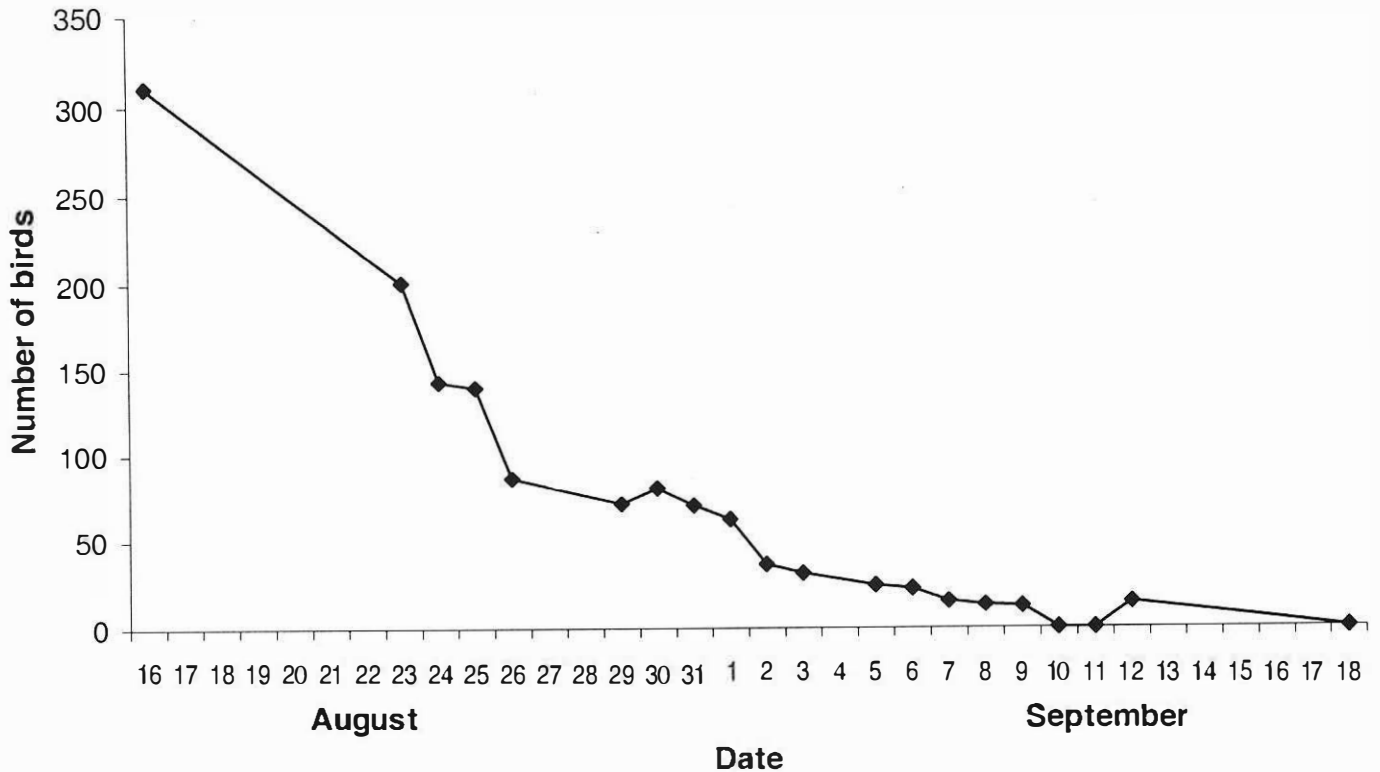


Figure 2. Changes in the size of a roosting colony of Rainbow Bee-eaters at Millner, Darwin August 16-September 18, 2000.

DISCUSSION

Locating roosts

The distribution of roosts suggests that all roosts in suburban Darwin were located during this study, although no attempt was made to follow birds foraging in the military base at Larrakeyah. The technique of following birds as they flew to their roost was a very effective means of locating roosts in urban areas where sufficient open areas exist to enable flying birds to be seen. It was less effective in open eucalypt or mangrove forest.

The association of roosts with two species of tree is more likely a reflection of the dominance of these species over other tall trees in urban parks and streets in Darwin, rather than a particular preference of Rainbow Bee-eaters for these trees. The density of foliage in these two tree species is quite different suggesting that this is not an important factor in selection of roosting tree.

Behaviour before, during and after roosting

The pattern of group size and movements observed at the Millner colony, despite the slight fluctuations in the size of the larger group, is suggestive of cohesion during both foraging and migration. Garnett (1985) also observed evidence of group cohesion, possibly family cohesion, during migration so it is not surprising that these groups also forage together.

The arrival of birds at the Moil and Leanyer roosts prior to or shortly after roosting birds began to depart suggests either that Rainbow Bee-eaters do not necessarily roost at the site nearest to where they forage or do not use the same

roost site every night. Perhaps these individuals were slow to fly to the roost on the previous night and were forced to roost away from the main group but returned to the roost the following morning to join the group before departure to foraging grounds. That the birds arrived from the same general direction as the nearest neighbouring roosting colony, viz Millner and Wanguri, however, suggests that they may have roosted with that colony.

Size of roosts and site fidelity

The density of Rainbow Bee-eaters in Darwin was higher than the estimate of 0.09 birds per hectare averaged over a 3 year period in mangrove forest near Darwin (Noske 1996). The relative dearth of Rainbow Bee-eaters for much of the year would undoubtedly have lowered this average and may explain this difference. The density (0.22 birds/ha) estimated in this study fits within the range of densities estimated by Woinarski *et al.* (1988) (0.12-1.0 birds/ha) during April/May (i.e. dry season) in woodland close to Darwin.

Rainbow Bee-eaters are very seasonal in Darwin (Thompson 1984) and the majority of birds observed during this study were likely to be migrants. The dramatic reduction in the size of the Nightcliff roost between June and August and the gradual decline in bird numbers at the Millner roost provides further evidence that migrating Rainbow Bee-eaters leave Darwin over a period of weeks rather than in one mass migration. Thompson (1984) recorded a dramatic reduction in the population of Rainbow Bee-eaters in Darwin from August levels of 90 birds seen per month to five birds per month in September but did not elaborate on how the population changes during August.

The interaction between resident and migrant birds was not studied, although some of the observations here may provide some insight. The stabilisation of the size of the Millner roost after 7 September following the steady decline observed over the previous weeks suggests that these birds were resident and that all migrants had departed by this date. The location of the roost became unstable after the departure of the migrants and was eventually abandoned. The inability to detect birds at the Moil and Wanguri roosting sites after September 4 suggests either that all birds from these colonies had migrated or that the colony had relocated and contained too few resident birds to enable its detection. The persistence of a small number of presumably resident birds after the departure of the migrants at Millner was also observed at the Nightcliff roost. This, however, contrasts with the observation at Casuarina Beach where a resident pair roosted in an area previously occupied by foraging migrants that roosted elsewhere. Whether these residents foraged and roosted with the migrants, foraged with the migrants but roosted separately or foraged separately only to move to Casuarina Beach after the departure of the migrants is unclear. Interaction between resident and migrant birds can probably only be clarified by radio-tracking individual birds.

Overcrowding of a roost because of cohabitation with other birds appeared to prompt the roost at Millner to move but this was only observed once during this study and is therefore unlikely to be commonplace. Cohabitation itself does not appear to bother roosting Rainbow Bee-eaters as they shared a tree at Nightcliff with at least 200 birds belonging to six other species. The reason for the change of roost at Millner is more likely due to the relatively crowded conditions in the small tree after the lorikeets began roosting there. Disturbance by passing vehicles may have contributed to the movement of the roost at Winnellie but roosting Rainbow Bee-eaters can be resilient to noise and light as evidenced by the roost outside the nightclub in Darwin.

Detection of a roost by predators may offer an explanation for the ephemeral nature of roosts. Bell (1970) observed disruption to a roost following attack by a goshawk which resembles that observed by the presence of a Barking Owl at Stuart Park.

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APPENDIX 1

Bird species seen sharing roost tree with Rainbow Bee-eaters at Nightcliff or observed at Millner prior to the first Rainbow Bee-eater leaving its roost site.

Nightcliff roost	Species active before Rainbow Bee-eater at Millner
Red-collared lorikeet <i>Trichoglossus haematodus rubritorquis</i>	Red-collared lorikeet
Figbird <i>Sphecothebes viridis</i>	Figbird
Pied Imperial Pigeon	Pied Imperial Pigeon
Bar-shouldered Dove <i>Geopelia humeralis</i>	Magpie-lark
Magpie-lark <i>Grallina cyanole</i>	Rufous-banded Honeyeater
Rufous-banded Honeyeater <i>Conopophila albogularis</i>	Australian White Ibis <i>Threskiornis molucca</i>
	Little Friarbird <i>Philemon citreogularis</i>
	Black Kite <i>Milvus migrans</i>
	Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>
	Brown Honeyeater <i>Lichmera indistincta</i>
	Blue-faced Honeyeater <i>Entomyzon cyanotis</i>
	Double-barred Finch <i>Taeniopygia bichenovii</i>
	Helmeted Friarbird <i>Philemon buceroides</i>
	Peaceful Dove <i>Geopelia striata</i>