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POPULATION DENSITY AND HOME RANGE ESTIMATES FOR THE EASTERN BRISTLEBIRD AT JERVIS BAY, SOUTH-EASTERN AUSTRALIA

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Twenty-two Eastern Bristlebirds *Dasyornis brachypterus* were radio-tracked at Jervis Bay. Densities at two sites were ≥1.5 and ≥2.1 birds/5 hectares respectively which were similar to previous aural surveys at Jervis Bay and to the maximum density of 2.4 birds/5 hectares recorded at Barren Grounds. The average home range minimum convex polygon area was approximately 10 hectares for the two birds tracked for more than 11 days. Home ranges overlapped and there was no evidence of individuals or pairs occupying exclusive territories during the non-breeding season. Management decisions which impact upon the Eastern Bristlebird will be flawed if they assume the species is confined to small exclusive territories throughout the year. Even small-scale disturbances in Eastern Bristlebird habitat are likely to impact upon numerous individuals.

INTRODUCTION

The conservation of threatened species depends upon soundly based population studies. For instance, the measurement of population density allows the estimation of total population size by extrapolation over areas of known or potential habitat. For threatened species, total population size and rate of change, especially a decline, are used to determine legal status and hence priority for conservation (e.g. Baker 1997). Home range measurement gives a convenient index of the area over which an individual animal normally travels in a given period (Burt 1943), although what constitutes normal travel and an appropriate time period for individuals or for a species, is open to interpretation (Burt 1943; White and Garrott 1990). Estimates of population density and individuals' home ranges can be used to predict and hence protect areas of potential habitat, particularly for threatened species.

The Eastern Bristlebird *Dasyornis brachypterus* is a small (40 g), brown, ground-dwelling inhabitant of very dense vegetation and it is shy and elusive. Because it is a cryptic species, all of the past studies have relied on detecting individuals by their loud distinctive calls and an occasional fleeting glimpse. The species occurs in south-eastern Australia and is highly fragmented with only two populations exceeding 500 individuals: Jervis Bay and Barren Grounds/Budderoo (Baker 1997). Calls have been used to map the positions of individual Eastern Bristlebirds from which population densities have been calculated and the total population has been estimated to be less than 2 000 individuals (Baker 1997). The species is listed as threatened nationally and in the states where it occurs: Queensland, New South Wales and Victoria. Home range of the Eastern Bristlebird has not been studied previously, although it has been assumed to be highly sedentary and to maintain small territories of 1–2 hectares (McNamara 1946; Blakers *et al.* 1984; Holmes 1989). My five-year study of 27 colour-banded Eastern Bristlebirds at Barren Grounds (unpubl. data) provided insufficient data to assess the validity of the previous estimates of population density or to characterize home range. Radio-tracking is an appropriate tool to study cryptic species (Macdonald and Amlaner 1980) like the Eastern Bristlebird. The aim of this study was to use radio-tracking to measure the population density and investigate home range of the Eastern Bristlebird at Jervis Bay, south-eastern Australia.

METHODS

The study was undertaken in 1997 and the methodology and effects of radio-tagging the bird have been reported in Baker and Clarke (1999). The species is sensitive to disturbance, particularly during breeding which occurs during August to February (Baker 1998; Baker and Clarke 1999) and so the study was undertaken during March to June.

Study area

The study was undertaken at three sites (A, B and C) in Booderee National Park, Jervis Bay Territory (Booderee), and two sites (D and E) in the New South Wales Jervis Bay National Park (JBNP). Each site had trails suitable for the erection of lines of mist-nets and for the subsequent ease of radio-tracking and mapping and was away from areas of high public visitation. The sites were located in areas where relatively high densities of Eastern Bristlebirds had been detected (Baker 1998).

Mapping

Location fixes were mapped manually in the field at a scale of 1:5 000 with an accuracy of ± 5 metres. This was possible because digitized maps were available which showed landscape features, trails and vegetation communities for Booderee (Taws 1997) and for JBNP (Mills 1993). At each site, the relative positions of features such as trail intersections and vegetation boundaries were ground truthed and flagging tape was used to mark accurately identified map positions. The fixes for each bird were stored in a database as map co-ordinates. The last two digits of the birds' band numbers were used to name individuals.

Generally, if an accurate fix is required when radio-tracking, it is desirable to follow the signal until the animal is sighted (Naef-Daenzer 1993). In other studies, this was possible with large or conspicuous birds such as the Brown Kiwi *Apteryx australis* (McLennan *et al.* 1987), nocturnal bird such as the Southern Boobook *Ninox novaeseelandiae* which can be spotlighted (Stephenson *et al.* 1998) and cryptic birds such as the Ground Parrot *Pezoporus wallicus* which can be flushed to confirm locations (Jordan 1988). However, the Eastern Bristlebird is both cryptic and sensitive to intrusion and hence, during tracking, they were rarely seen or intentionally disturbed.

Tracking was conducted on foot and began on a trail by estimating the general location of the signal. Adequate trail access, flat terrain and short tracking distances facilitated locating the birds and minimized the errors of the fixes. To pin-point the fix, 2–4 bearings were mapped in quick succession. If necessary, closer tracking was undertaken by moving off the trail and circling the location at a radius of approximately 25 metres. Sometimes when tracking a bird, its location could not be fixed because it was distant from a trail or moving through its habitat more quickly than the observer could obtain successive bearings.

To ensure independence, 20 minutes was allowed between most fixes, although 4 per cent of fixes (33/782) were taken within 20 minutes and were considered independent because they were ≥25 metres apart. Other fixes were considered to be autocorrelated and they were discarded. These *post hoc* decision rules for the independence of fixes were based on the time being sufficient for a bird to traverse a home range and the distance being relative to the scale of interest in the study. A 10 hectare circle has a diameter of 360 metres and there was an instance of a bird being tracked over 320 metres in less than 20 minutes, although Eastern Bristlebirds are most likely to be able to traverse such distances more quickly.

Population density

For sites A and B the number of Eastern Bristlebirds trapped was taken to be the minimum number of birds at each site. The total areas of site A and site B were taken as the convex polygons that contained all of the tagged bird locations at the sites. For sites C, D and E no density estimates were calculated because only two Eastern Bristlebird were trapped.

Home range

In home range studies which use radio-tracking, the most usual home range index is the minimum convex polygon (MCP) (Harris *et al.* 1990). This index is often credited to Mohr (1947), although it is intuitive and simply the convex polygon enscribed by the outermost locations noted for an animal in a specified time period. The estimate of the home range of an animal is dependent on the period of time spent collecting data (Spencer *et al.* 1990). Using a MCP area to calculate home range has the advantages of being simple and comparable among studies. The main disadvantages are that the home range is underestimated if an animal's normal behaviour is under-sampled and overestimated if the animal normally does not use parts of the MCP area. The latter situation can arise if the animal makes long-distance sallies outside its normal range. The problem of outliers can be overcome by using nonparametric methods of estimating home range such as the kernel method (Worton 1987; Kie *et al.* 1994) based on the utilization distribution (UD) of fixes. By specifying varying utilization levels, outliers can be omitted progressively (e.g. 90% UD, 75% UD) and areas of intense home range usage can be identified (e.g. 50% UD). Ideally, regardless of the method of measurement, the home range area should approach an asymptote within the period of collecting fixes.

The software package CALHOME (Kie *et al.* 1994) was used to calculate and draw MCP and 90 per cent, 75 per cent and 50 per cent UD home range areas.

For each bird, the cumulative home range area was calculated for each successive day of tracking. To determine the number of fixes per bird required to approach an asymptote of home range area, the total cumulative home range area for each bird was plotted against its total number of fixes. To determine the number of days of tracking data required to approach an asymptote of home range, each bird's cumulative home range area was plotted against the number of days of tracking, for individual birds which were tracked for ≥7 days.

The overlap of individual home range MCP areas of the birds tracked at sites A and B was quantified using the index proposed by Horsup (1994), expressed as a percentage:

Percentage mean overlap of home range areas:
X and $Y = 100\{[X \cap Y]/X + [X \cap Y]/Y\}/2$;
where $[X \cap Y]$ = the area of home range overlap between X and Y.

RESULTS

Mapping

Twenty-two radio-tagged birds were tracked opportunistically for 1–28 days (median 5 days, mean 7 days) (Table 1). Some birds were not tracked on every day that they were tagged. There were 1–111 fixes per bird, with an average of five fixes per bird per day (range 1–18) (Table 1). The point of capture was not taken to be a fix, although the 19 birds that were tracked for more than a day were captured within or near (20–60 metres outside) the area enscribed by their subsequent fixes (Table 1).

Population density

At site A, 14 Eastern Bristlebirds were trapped within 22 days and tracked during 34 days. This gave a density of at least 14 birds in 48 hectares (≥1.5 birds/5 ha). At site B, eight Eastern Bristlebirds were trapped within six days

TABLE 1

Radio-tracking data collection and home range areas.[a] d is the distance of the trapping point to the MCP when it was not within the home range MCP area. [b] MCP is the minimum convex polygon. [c] UD is the utilization distribution.

Bird	Tracking days of data	Fixes total	Fixes max/day	d[a]	Home range area (ha) MCP[b]	90% UD[c]	75% UD	50% UD
#51	6	33	9		2.6	2.9	1.4	0.42
#52	3	15	7		4.6	5.5	3.6	0.81
#53	5	25	9	(20 m)	5.8	6.2	4.8	1.6
#54	3	17	8		2.4	2.8	1.7	0.47
#55	21	107	11		11.6	7.0	3.8	1.7
#56	3	16	9	(45 m)	1.2	2.0	1.1	0.23
#57	11	59	13		2.8	3.1	1.6	0.63
#58	5	17	7	(60 m)	1.8	2.5	1.5	0.32
#59	1	1	–			–	–	–
#60	1	1	–		–	–	–	–
#61	1	3	–		1.5	–	–	–
#62	10	56	9	(20 m)	3.2	3.1	1.8	0.64
#63	5	26	8		1.9	2.2	1.3	0.76
#64	9	45	10		2.7	2.9	1.7	0.82
#65	5	25	10		4.0	6.3	2.8	1.2
#66	5	25	7		2.2	2.2	1.1	0.37
#67	7	48	9	(25 m)	6.6	7.4	4.3	1.1
#69	5	26	9		1.8	2.0	1.5	0.58
#70	6	42	11		5.0	5.8	4.0	2.0
#71	11	59	12		4.8	4.1	2.9	1.6
#72	4	25	8		3.6	3.4	2.5	1.4
#73	28	111	18		9.6	7.3	4.9	2.2

and six of these were tracked during the 19 days. This gave a density of at least eight birds in 19 hectares (≥2.1 birds/5 ha). At both sites, up to five birds were tracked simultaneously. One bird was tracked at each of sites C and E and no birds were tracked at site D.

Home range

There were ≥15 fixes for 19 birds. Home range MCP areas were 1.2 hectares (16 fixes) to 11.6 hectares (107 fixes); the 90 per cent UD home range was 2.0–7.4 hectares; the 75 per cent UD home range was 1.1–4.9 hectares; and the 50 per cent UD home range was 0.23–2.2 hectares (Table 1). The results for birds #57 and #73 illustrate the different methods of calculating home range area (Fig. 1).

The home range MCP area was roughly proportional to the number of fixes (Fig. 2) and similar patterns were observed for the 50, 75 and 90 per cent UD areas. The home ranges of the Eastern Bristlebirds were under-sampled. This is shown by the lack of asymptotes in the cumulative home range areas of individual birds with the exceptions of birds #55 and #73 (Fig. 3). Birds (n = 7) for which there were tracking data for at least 7 days had home range MCP areas averaging 4.0 hectares (range 1.5–6.6 ha). Birds (n = 5) for which there were at least 10 days of tracking data had home range MCP areas averaging 5.2 hectares (range 2.8–8.7 ha). Bird #55 was tagged for 22 days and, from 21 days of tracking data, its home range MCP area was 11.6 hectares. Bird #73 was tagged for 41 days and, from 28 days of tracking data, its home range MCP area was 9.6 hectares.

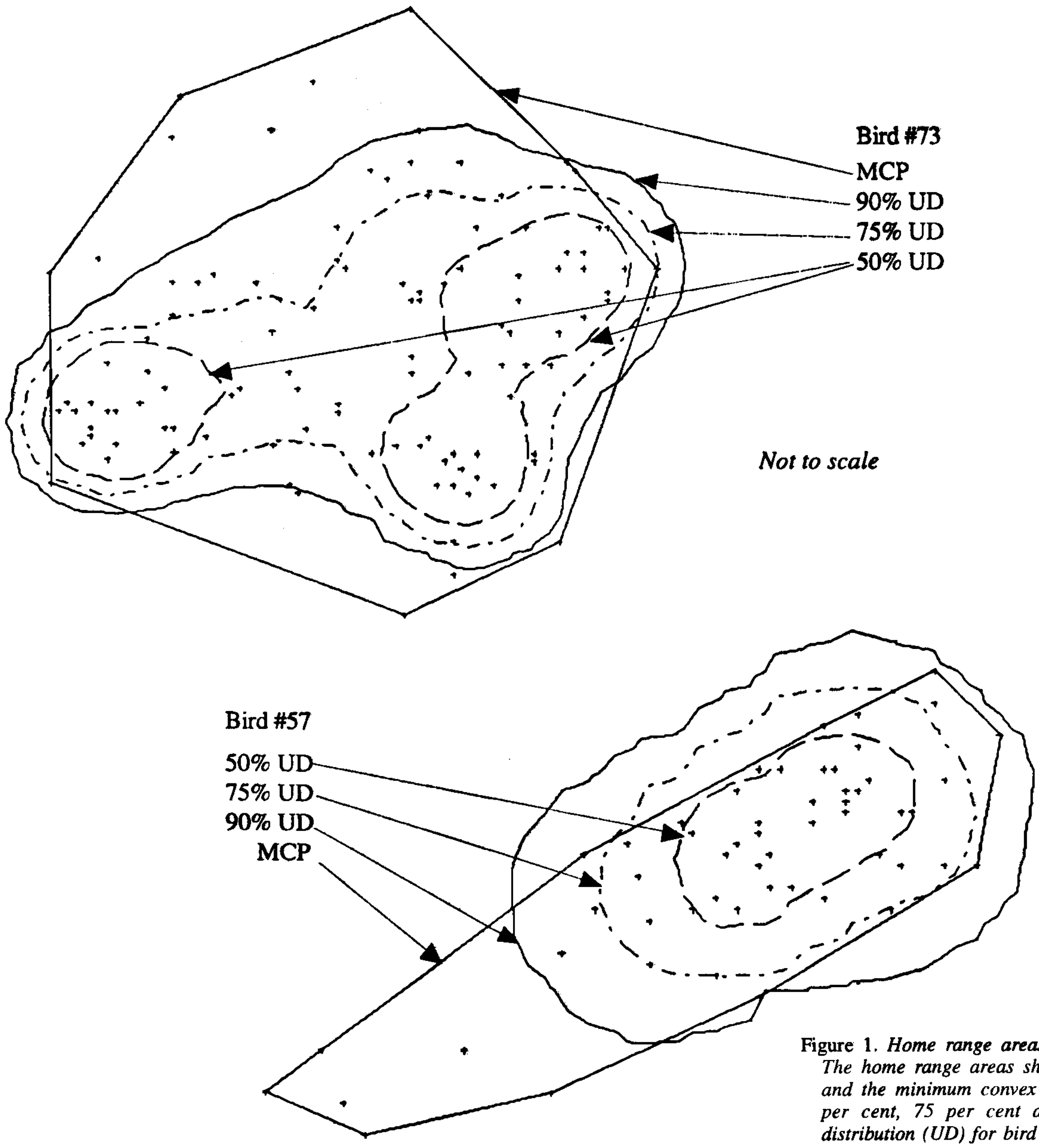

Figure 1. *Home range areas of bird #57 and bird #73. The home range areas show the location of fixes (+) and the minimum convex polygon (MCP) and the 90 per cent, 75 per cent and 50 per cent utilization distribution (UD) for bird #73 and bird #57.*

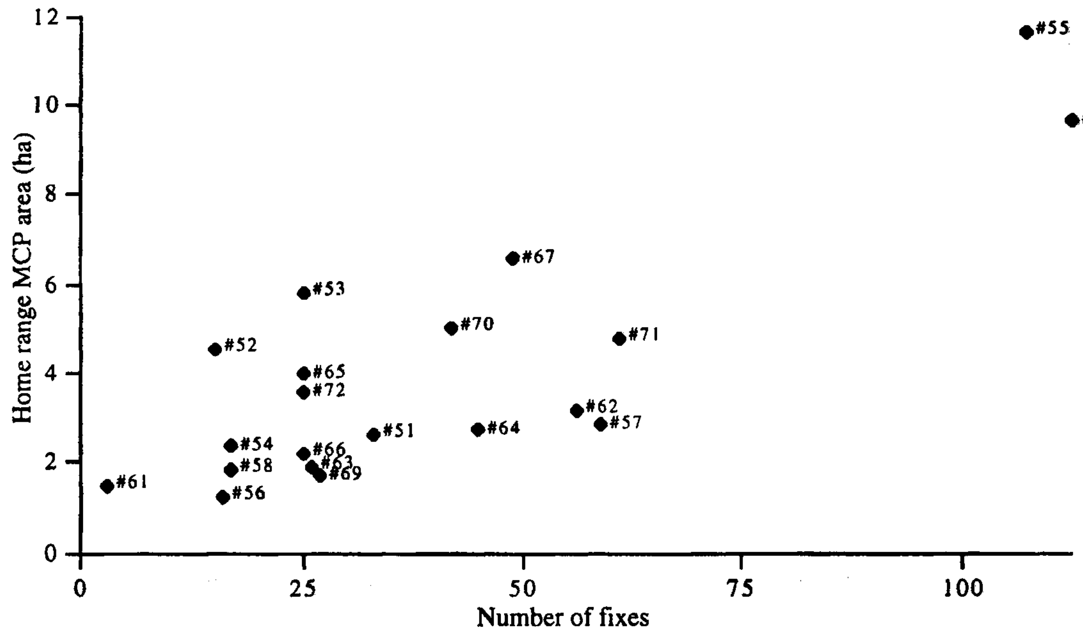

Figure 2. *The effect of sample size on home range MCP area. Sample sizes range from three fixes for bird #61 to 111 fixes for bird #73.*

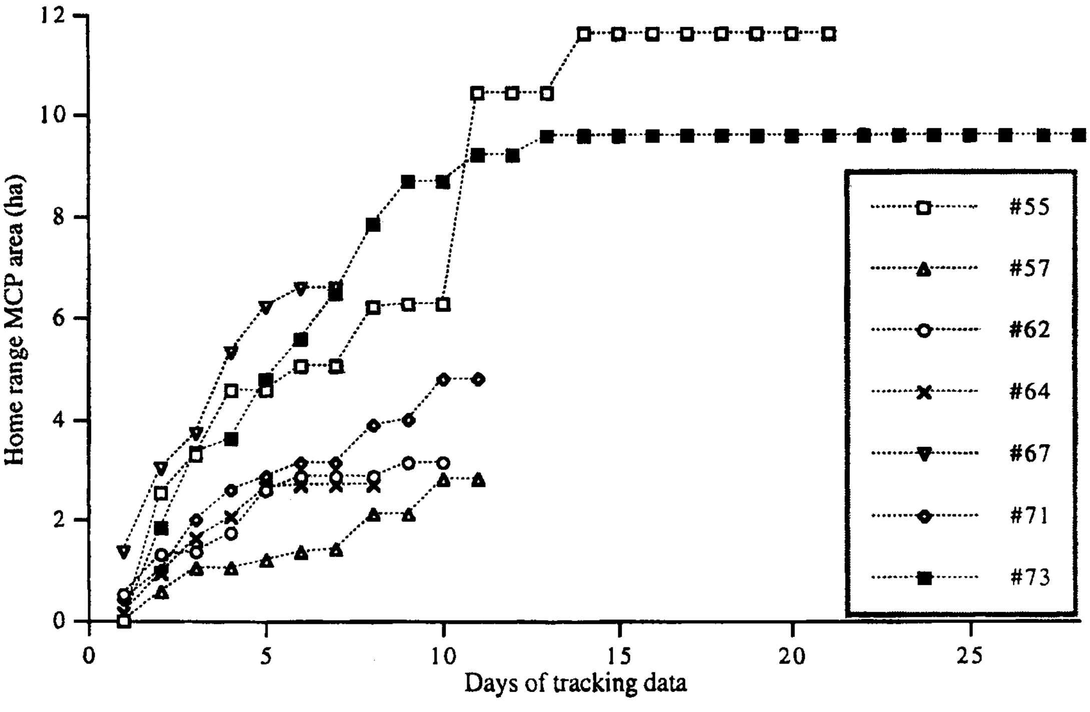

Figure 3. *Daily cumulative home range MCP areas of the seven birds for which there was ≥7 days of radio-tracking data.*

The pattern of overlap of the individual MCP home ranges of the birds tracked at site B is shown in Table 2. Generally, neighbours were irregularly spaced with one home range overlapping 2–5 others and overlap was 0–80 per cent. The pattern is incomplete because two birds caught at the site were not tracked, the period of tracking was brief for most birds and tracking was discontinuous and sometimes asynchronous. A similar pattern was evident at site A: home range MCP area of individuals overlapped 1–6 other birds and overlap was 0–60 per cent.

DISCUSSION

Density of Eastern Bristlebird populations

Results from an earlier study of Eastern Bristlebirds at Jervis Bay (Baker 1997) gave densities of 1.4 and 1.6 birds/5 hectares compared to the present study which gave ≥1.5 and ≥2.1 birds/5 hectares for sites A and B respectively. In the ≥15 months between the two survey periods, the density estimates have increased by 7 per cent at site A and 31 per cent at site B. There are four plausible

TABLE 2
Percentage overlap of home range MCP areas of birds #67–#72 at Site B.

#67	50%				
#69	0	10%			
#70	10%	40%	60%		
#71	0	0	20%	20%	
#72	0	20%	70%	80%	30%
	#66	*#67*	*#69*	*#70*	*#71*

explanations. (i) The population may be unchanged but the earlier aural survey detected less birds than the radio-tracking study. A similar result was obtained by Novoa (1992) who detected 75 per cent of his radio-tagged Grey Partridge *Perdix perdix* by their call alone. (ii) The population may be unchanged and the apparent difference between the two survey periods may be due to inherent errors of measurement. For transects at Barren Grounds, Baker (1997) calculated standard errors of 8.9–35 per cent of mean densities of the Eastern Bristlebird. (iii) The increase may be real but temporary due to the post-breeding influx of juveniles, many of which may not survive to the following spring. One of the birds caught at site B may have been a juvenile (Baker and Clarke 1999). (iv) The increase may reflect a real, long-term trend. This may have been possible due to the relative lack of disturbance to Eastern Bristlebird habitat at Jervis Bay during 1994–1997. In the absence of disturbance from fire at Barren Grounds during 1991–1996, Baker (1997) found that the Eastern Bristlebird population increased at an average of 14 per cent per annum.

There is a relatively small and plausible difference between the Eastern Bristlebird population density calculated for the earlier aural survey and the present radio-tracking study. Furthermore, the maximum density at Barren Grounds based on aural surveys conducted in late summer (ie post-breeding) was 2.4 (se = ± 0.29) birds/5 hectares (Baker 1997) which is similar to the density calculated from the radio-tracking study at Jervis Bay. These comparisons, together with the general pattern of movements and home range areas calculated from the radio-tracking data, provide confidence that aural surveys are valid estimates of actual Eastern Bristlebird densities.

Home range

The home ranges of the Eastern Bristlebirds in the present study may be described as having MCP areas averaging 4 hectares (range 1.5–6.6 ha) for one week and ≥10 hectares for 2–6 weeks. While recognizing that the period of the study was brief, my preliminary estimate is that Eastern Bristlebirds have an average home range MCP area of approximately 10 hectares. This is at the upper limit of home range size found for other omnivorous-insectivorous passerines considering their weight and daily energy requirements (Schoener 1968; Mace and Harvey 1983). Also, this estimate is consistent with the furthest daily movement between two fixes of 525 metres (Baker and Clarke 1999) and the record of one banded bird at Barren Grounds for which two sightings approximately one year apart were separated by 600 metres (unpubl. data). Given the movements and home range areas of the Eastern Bristlebirds at Jervis Bay, it is not surprising that a small number of Eastern Bristlebirds are road-killed every year.

The results of the present work are comparable to results for the Western Bristlebird *D. longirostris*, which weighs 75 per cent of the Eastern Bristlebird. Smith (1987) estimated from aural surveys that Western Bristlebird pairs occupied irregular amoeboid-shaped home ranges of 6–8 hectares and Murphy (1994) radio-tracked two birds which had MCP areas of 6 and 21 hectares. There is no published home range estimate for the Rufous Bristlebird *D. broadbenti* but it is a larger animal than the Eastern Bristlebird and I predict that its home range exceeds 10 hectares.

The kernel method of describing the shape and area of the home range is conservative in terms of the Eastern Bristlebird's ecology. The present study was confined to a brief period of radio-tracking within a single population and does not account for the likely differences among locations (Laidlaw and Wilson 1996) or the likely changes in ranging behaviour which may occur in different seasons (Spencer *et al.* 1990) and with different times in the breeding cycle (Grahn 1990; Spencer *et al.* 1990; Chandler *et al.* 1994; Montadert 1995). Furthermore, areas of apparently intense home range use, such as the 0.23–2.2 hectares of the 50 per cent UD area (Table 1) or the 'core areas' of 1–3 hectares calculated for the Western Bristlebird (Smith 1987), omit infrequently used but nevertheless important parts of an animal's home range, for example a drinking point visited for only one minute each day (North and Reynolds 1996). For instance, bird #57 was tracked making brief (<1 hour) sallies to the south-western end of its home range on three consecutive days and the fixes for these movements are excluded from the 90 per cent UD (Fig. 1). However, such sallies may be vital to population dispersal and gene flow (Koenig *et al.* 1996).

The results provided no evidence of individuals or pairs of Eastern Bristlebirds in exclusive territories during the non-breeding season. At Barren Grounds and Jervis Bay, the Eastern Bristlebird co-occurs with the Ground Parrot which lives in dense heathland. In a radio-tracking study in south-eastern Queensland, McFarland (1991) found no evidence to suggest that Ground Parrots maintain exclusive territories. He concluded that their dense habitat and cryptic terrestrial lifestyle would make defence of their 6–14 hectares home range too costly in time and energy. Similarly, Eastern Bristlebirds have a cryptic terrestrial lifestyle in dense habitat and it is likely that they have broadly overlapping home ranges and that they expend little or no effort defending territories throughout the year.

Conservation management

In the Jervis Bay region, there is continuing pressure for urban, tourist and infrastructure development in Eastern Bristlebird habitat and potential habitat. The area of a development can be maximized if, when undertaking impact assessment, it is successfully argued that pairs of Eastern Bristlebirds are sedentary in small (1–2 ha) exclusive territories. The present study found that Eastern Bristlebirds have large (≥10 ha) overlapping territories in the non-breeding season and they may undertake large (>500 m) daily excursions. Furthermore, the species is found in a wide range of vegetation types in the mosaic of native vegetation at Jervis Bay (Baker 2000). These results imply that (i) management decisions which impact upon the Eastern Bristlebird will be flawed if they assume the species is confined to small exclusive territories throughout the year and (ii) even small-scale disturbances in Eastern Bristlebird habitat are likely to impact upon numerous individuals.

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