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Impacts on a threatened bird population of removals for translocation

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Abstract

The removal of individuals from a population may occur for several reasons and responses of populations will vary depending on the magnitude and nature of the removal and the life history of the species. An understanding of the effects of loss of individuals on these populations, and the mechanism of replacement, will be important to conservation. This maybe particularly important where wild individuals are used for the increasingly popular conservation strategy of translocation. During the recent translocation of the endangered eastern bristlebird (Dasyornis brachypterus), two monitoring sites were established in the wild source population, one where removals were to take place and another as a control to assess the impact of the removals on the population. The removal of 44 eastern bristlebirds across 3 years from a single area in the source population had no significant detectable impact in the numbers of individuals surveyed. Individuals that were removed appeared to have been replaced within 6 months of their removal, although to a lesser extent in the later part of the study. The origin of the replacement eastern bristlebirds was unknown and the quick recovery was suggested to be a result of juvenile dispersal, perhaps combined with territory uptake by previously non-territorial and non-calling (thus undetectable) individuals within the population. Such a surplus may be a result of insufficient suitable habitat for population expansion, and will also have implications for monitoring populations of rare and cryptic species. It is also suggested that some territorial species may have several mechanisms that can replace losses of individuals from a population.

Keywords

bird, population, removals, threatened, translocation, impacts

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Impacts on a threatened bird population of removals for translocation

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The removal of individuals from a population may occur for several reasons and responses of populations will vary depending on the magnitude and nature of the removal and the life history of the species. An understanding of the effects of loss of individuals on these populations, and the mechanism of replacement, will be important to conservation. This may be particularly important where wild individuals are used for the increasingly popular conservation strategy of translocation. During the recent translocation of the endangered eastern bristlebird (*Dasyornis brachypterus*), two monitoring sites were established in the wild source population, one where removals were to take place and another as a control to assess the impact of the removals on the population. The removal of 44 eastern bristlebirds across 3 years from a single area in the source population had no significant detectable impact in the numbers of individuals surveyed. Individuals that were removed appeared to have been replaced within 6 months of their removal, although to a lesser extent in the later part of the study. The origin of the replacement eastern bristlebirds was unknown and the quick recovery was suggested to be a result of juvenile dispersal, perhaps combined with territory uptake by previously non-territorial and non-calling (thus undetectable) individuals within the population. Such a surplus may be a result of insufficient suitable habitat for population expansion, and will also have implications for monitoring populations of rare and cryptic species. It is also suggested that some territorial species may have several mechanisms that can replace losses of individuals from a population.

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Impact of removals on a threatened bird population

D. Bain and K. French

Introduction

Loss of individuals from a population may occur because of predation, environmental stochasticity, catastrophe or anthropogenic activity. The impact of this loss on a population will depend on the magnitude and nature of the loss, and on the life history of the species. An increased loss of individuals from a population would be expected to decrease local population densities and may increase the probability of local extinctions. As such, an understanding of the influence of losses from populations has importance to conservation and to understanding population dynamics.

For animals that maintain territories, often the loss of individuals does not change local population densities. In a removal experiment off the coast of Wales, Harris (1970) found that territorial behaviour, and not an equilibrium between mortality and juvenile recruitment, was maintaining a population of oystercatchers (Haematopus ostralegus) at between 49 and 52 breeding pairs for over 5 years. In a similar experiment on American redstarts (Setophaga ruticilla), Sherry and Holmes (1989) found that when 15 males were removed, they were replaced by 15 males of mixed ages. The suggestion that territorial behaviour was the main factor determining the number of birds in both populations has been supported by other studies (Wesolowski 1981; Cederholm and Ekman 1976; Mönkkönen 1990). Of 59 removal studies in territorial species reviewed by Newton (1992), 27 reported over 75% replacement of removals, and of these, six reported greater than 100% replacement. Only 7 of the 59 studies reported no replacement. The replacements were often said to be coming from a pool of non-territory holders or ‘floaters’ (Newton 1992).

The maintenance of a stable population density in territorial birds following the loss of individuals will be influenced by the magnitude of the event causing the loss. The rate of vacation of territories can influence the sizes and numbers of territories in an area. Knapton and Krebs (1974) found with song sparrows (Melospiza melodia) that if all territory holders were removed at once, the replacement territories were smaller because of more territories being established in the same area at the same time. However, if territory holders were removed one at a time, the replacement territories were the same size as others before the removal.

Translocation of individuals to establish or re-establish populations has become a common conservation strategy that is growing in popularity (Griffith *et al.* 1989; Fischer and Lindenmayer 2000). Often this involves the removal of individuals from wild populations. For example, in their review of published accounts of animal relocations, Fischer and Lindenmayer (2000) listed 45 translocations involving wild-caught individuals between 1980 and 2000. Understanding the impact of such removals on the source population is important for assessing the efficacy of translocation from the wild for species conservation, because it is crucial that the viability of the source population not be compromised (McCarthy 1994; Kleiman *et al.* 1994). However, post-removal monitoring of source populations is typically not reported in published accounts (although see Danks 1994; Friend and Thomas 1994; Armstrong and Craig 1995; Pickett 2002).

As part of recent conservation efforts, the eastern bristlebird (*Dasyornis brachypterus*) was reintroduced into part of its former range at Jervis Bay, on the south-eastern coast of Australia. Founding individuals for the translocation were sourced from a nearby wild population over 3 years. With concern for the source population from which eastern bristlebirds were removed, and in an effort to understand more about the species, a monitoring study was carried out in the source population. This provided an opportunity to investigate the impact of a sustained removal of individuals from an eastern bristlebird population. Specifically, we tested the hypothesis that removals will reduce densities and cause a change in the distribution and population structure of eastern bristlebirds in the source population.

Methods

The study was conducted at Bherwerre Peninsula, Jervis Bay (35°04′S, 150°45′E), on the south-eastern coast of Australia. The source population ranges over ~4300 ha on the western side of the bay. Two sites in the source population were investigated, a 'removal' site and a 'control' site, 2 km apart, encompassing ~500 ha and 400 ha of habitat respectively. The design initially incorporated two removal and two control sites; however, a large wildfire prevented this replication. This fire burnt ~3000 ha within Booderee National Park at Jervis Bay. The removal site was not affected, although approximately half of the control site was burnt. At the remaining removal site, eastern bristlebirds were caught and removed with the use of mist nets and call playback along service trails. There were three removal periods, 2003, 2004 and 2005, removing 16, 20 and 8 birds respectively. Eastern bristlebirds become more vocal around the breeding season (September–February). Removals were planned approximately 2 months after the breeding season (April) to maintain reasonable capture success while trying to avoid removing birds caring for dependent young.

The removal and control sites were surveyed annually in October from 2002 to 2005. Two additional surveys were also conducted during January in 2004 and 2005. Survey methods followed closely those of Baker (1997) and involved listening for birds while walking at 2–4 km h^{-1} and simultaneously mapping on topographic maps the number and positions of eastern bristlebirds seen or heard. Eastern bristlebirds can be reliably mapped by a competent observer up to 250 m away, the distance considered the edge of the survey area (Bain and McPhee 2005). Surveys were conducted along four transects (length = 500 m) spaced at least 500 m from each other at the removal site and two transects (lengths = 1865 and 1600 m) similarly spaced at the control site. Differences in lengths were associated with a need to maintain independence among survey transects and the difficulties on the layout of the tracks. These transects were treated as independent replicates because it is expected that eastern bristlebirds would not move >500 m in the 15–30 min taken for an observer to traverse that distance and their calls cannot be heard over that distance. The maximum distance eastern bristlebirds have been recorded moving in 1 h is 330 m (Baker 2001). Surveys were repeated at the same time of the year to avoid any seasonal changes in detection probability of the birds (MacKenzie and Kendall 2002).

Throughout the study and the ensuing data analyses, sample sizes were necessarily small. This was a direct result of dealing with a rare species. Increasing sample sizes was not feasible because of the over-arching principle of minimising impacts on this threatened species.

Because detection was difficult with this cryptic species, surveys were repeated on four separate mornings during a 4-week period to evaluate the level of variation among the surveys. The greatest difference among mornings within a survey period in the total numbers of birds recorded was between 17 and 28 birds. The morning on which the maximum number of eastern bristlebirds was recorded during the survey period (across all transects) was used for data analysis as the most accurate indication of density. The maximum was considered the most accurate because it indicates that there is 'at least' this many birds along the transect. Repeated-measures analysis of variance was used to examine changes in the numbers of eastern bristlebirds before and after the removals.

To investigate changes in the size of territories, nearest-neighbour data were recorded, with eastern bristlebirds found as duetting pairs (calling to one another) considered as one bird for the analysis. In these cases, the mid-point of the two was used as the data point because these birds were never far apart. Nearest-neighbour distances were recorded on both sides of the transects for the survey period that recorded the maximum number of birds (as above). Repeated-measures analysis of variance was used to investigate any differences in the average nearest-neighbour distances from year to year. The distributions of nearest-neighbour distances were fitted to a Poisson distribution to examine whether they were distributed randomly (Zar 1984). The goodness-of-fit of the Poisson distribution was examined with Kolmogorov–Smirnov one-sided exact tests. Kolmogorov–Smirnov two-sample tests were then used to compare the distribution of nearest-neighbour distances from eastern bristlebirds between control and removal sites and before and after the removals. Because multiple comparisons were undertaken between years and between sites, a Bonferroni correction (Zar 1984) was also applied to the data.

The sex ratio and morphometrics of removed eastern bristlebirds that were measured as part of routine data collection for the translocation, were later used to investigate whether any changes were occurring in the population, with losses of individuals as part of a post hoc analysis. Any changes in the sex ratio of the birds caught may indicate a broader change across the population and changes in the sizes of birds may indicate broader changes in the age structure or population health. The sex of eastern bristlebirds was determined genetically from feather samples (see Bain

2007). The sex ratio of eastern bristlebirds caught during the 3 years was examined with a chi-square test. The expected ratio was obtained from a contingency table. We measured weight, tail length, wing length and head–bill length and compared differences among the 3 years with ANOVA.

Results

The number of eastern bristlebirds in treatments during the 3 years did not differ (interaction term: $F_{5,20} = 0.812$, $P = 0.555$) (Fig. 1). No significant differences were found between removal and control sites ($F_{1,4} = 0.35$, $P = 0.861$). However, between October 2003 and January 2004 there was a significant increase of 1.4 eastern bristlebirds per 500 m at both the control and removal sites ($F_{1,4} = 11.391$, $P = 0.028$).

Although average nearest-neighbour distances appeared to increase at the removal site and decrease at the control site across the 3 years of removals (Fig. 2), the interaction between time and site was not significant ($F_{3,90} = 2.212$, $P = 0.092$). Changes over time were not statistically significant either ($F_{3,90} = 2.225$, $P = 0.091$), although the difference between the control and removal sites approached significance ($F_{1,30} = 4.049$, $P = 0.053$). There was a significant change over time in the average nearest-neighbour distances from 2002 to 2003 ($F_{1,30} = 5.071$, $P = 0.032$), with the distance for the removal site decreasing by 60 m and for the control site by 8 m (Fig. 2). However, the interaction between time and site suggested that there were no spacing differences between the sites during this period ($F_{1,30} = 2.736$, $P = 0.109$). From 2003 to 2004, there was another significant change through time ($F_{1,30} = 4.829$, $P = 0.036$), with the average nearest-neighbour distance at the removal site increasing by 55 m and that at the control site by 6 m. Again, the interaction between time and site showed that the difference between the sites was not significant during this period ($F_{1,30} = 3.856$, $P = 0.059$).

At all times and at both sites, the distribution of the nearest-neighbour distances was significantly different from a Poisson distribution (Fig. 3, Table 1), suggesting that the birds were not randomly distributed. Fig. 3 suggests that the distributions were close to uniform, except in 2004 and 2005 at the removal site where the distribution had become bimodal. To examine whether the distribution changed as a result of the removals, the distributions of nearest-neighbour distances were compared against each other for change over time or between sites. Without applying a multiple-comparison correction, there was a significant difference between years 2002 and 2003 ($P = 0.01$, Table 2), and between 2003 and 2005 ($P = 0.01$, Table 2) at the removal site. This difference was not significant when the multiple-comparison correction was applied to the data. However, a trend showing a difference between these years is also observable in Figs 1 and 3. There were no other differences among time periods or between sites (Table 2). The results suggest that at the removal site, eastern bristlebirds were closer together in 2003 than they were before removal in 2002 or after all three removals in 2005 (Fig. 3).

The sex ratio of removed eastern bristlebirds did not change during the 3 years ($\chi^2 = 0.19$, d.f. = 2, $P > 0.1$) (Table 3). The wing lengths of male eastern bristlebirds varied significantly during the three removals ($F_{2,24} = 3.869$, $P = 0.035$). A Tukey HSD post hoc test revealed that the significance ($P = 0.027$) was due to a decrease in the male wing lengths from 76.4 ± 1.8 (mean ± s.d.) mm in 2003 to 73.5 ± 2.6 mm in 2004. There was no other variation in the morphometrics measured in either males or females among any of the years.

Discussion

Despite clear trends in the data, the lack of significance of many of our results was strongly influenced by the power and sample size. As a result, we suggest that the trends are important to consider because lack of power is an inherent problem in dealing with rare species and an increase in sampling is often not achievable because of a lack of suitable sites or individuals to survey.

The loss of individuals from a population may be expected to exacerbate local extinction rates or lower reproductive output. However, following the removals of eastern bristlebirds from the wild population at Bherwerre Peninsula, there were only moderate impacts on eastern bristlebirds, with no detectable change in overall numbers despite other metrics suggesting some changes. In a similar response to the removal of individuals, Cederholm and Ekman (1976) observed no differences in density between control and removal sites 6 months after the removal of crested tit (*Parus cristatus*) and willow tit (*Parus montanus*). Removed eastern bristlebirds were presumably largely replaced each time either from immigration, new recruits from the recent breeding season or from a population of cryptic adults who do not hold breeding territories and call less frequently, and are thus not being included in call-based density estimates.

The sex ratio of the birds that were caught, i.e. those individuals that responded to call-playback and presumably territory holders, did not change during the experiment. Because an equal number of males and females were caught by the same trapping technique, it is assumed that there was no set bias in trapping success. Birds were rarely caught in pairs; most often single birds were caught at any one time in any one location. Subsequent return visits often resulted in another bird being caught in the same location. The suggestion for the lack of change in the sex ratio in relation to trapped individuals is that neither sex is placing a limit on the number of territories within the population. If vacant habitat is available, the occupation of that habitat by a pair should be limited only by population number and not the availability of a mate.

Replacement appeared to occur completely in the first year, whereas it was incomplete in the following years, suggesting that fewer replacement individuals were available. Eastern bristlebirds were uniformly distributed in all years at the control site, whereas at the removal site the distribution of the nearest-neighbour distances became bimodal in 2004 and 2005, suggesting that eastern bristlebirds were starting to become aggregated in their distribution through the habitat, possibly as numbers contracted and territories became vacant. Although overall numbers changed little throughout the removals, the pre-removal spacing of birds was not evident by the end of the study. This may be a result of inexperienced eastern bristlebirds occupying vacated territories.

Following the second removal, in 2004, there was a non-significant drop in the numbers of calling birds, and in contrast to the situation after the first removal, there was an increase in the average nearest-neighbour distances at the removal site, suggesting a lower degree of replacement of removed individuals in 2004 than in 2003. If there are inadequate numbers of replacement birds, then spaces might be evident or territories might expand (e.g. willow warblers Arvidsson and Klaesson 1984). In the present study, the increase in the average nearest-neighbour distances suggested that there may have been fewer eastern bristlebirds than before the removal; however, we could not assess whether there were vacant spaces or increased territory sizes.

Interestingly, the probable movement of eastern bristlebirds in response to a nearby fire (Bain *et al*. 2008) seemed to influence the results of the present removal study during the second removal. There was a significant increase in the numbers of eastern bristlebirds at the removal site just before the second removal, resulting in an increase in available birds. The pre-removal increase was attributed to a nearby wildfire, because escaping eastern bristlebirds may have migrated into this area. The movement of birds away from a fire and from the resulting burnt habitat is well documented in the literature (Wooller and Calver 1988; Burbidge 2003) and happened quickly here (Bain *et al*. 2008). These displaced individuals generally return when conditions become more suitable (Woinarski and Recher 1997; Burbidge 2003), which was observed here with the numbers of eastern bristlebirds in the burnt area away from the removal site approaching pre-fire levels just 9 months after fire (Bain *et al*. 2008). Despite the temporary increase in the number of available birds, incomplete replacement was still evident. The conclusion from this was that the fire had little overall effect on the replacement of removed eastern bristlebirds in this second year of removals.

After the third removal, nearest-neighbour distances were greater than in 2003, although this was not significant when a multiple-comparison correction was applied to the data (Table 2). More eastern bristlebirds were further apart in 2005 than in any other year (Fig. 3), although there was no statistical difference between the control and removal sites (Table 2, Fig. 3). Again it is unclear whether this trend towards an increased distance between eastern bristlebirds was a result of vacant spaces or increased territory sizes.

There were more replacements of removed individuals throughout the present study than was expected from the numbers of eastern bristlebirds surveyed. Some replacements are likely to have been a result of dispersing juveniles, as removals occurred approximately 2 months after the breeding season of the eastern bristlebird. Additionally, there was a significant reduction of 2.8 mm in the average wing length of captured males from 2003 to 2004, although there were no other changes in morphological measurements taken from removed eastern bristlebirds. Mönkkönen (1990) found a decrease in the tarsus and wing length across all species caught (>9, exact number not specified), which was associated with a change in the age structure after removals.

Although many replacements were probably by dispersing juveniles, several lines of evidence suggested that at least some were by other means. First, the reduction in wing length was not accompanied by a reduction in any other morphometrics. As with other experiments (Mönkkönen 1990), a change in the age structure of birds would presumably be evidenced by a change in a range of morphometrics. However, these measurements were recorded ~12 months after removals and like many of the life attributes of eastern bristlebirds, growth rates are not well understood (Higgins and Peter 2002). Second, the low fecundity of eastern bristlebirds means that the number of juveniles present is considered to be limited (Higgins and Peter 2002) and unlikely to have provided the necessary numbers of individuals to replace those removed. Third and finally, the replacements following the first two removals seemed to occur at the beginning of the breeding season, before the period of juvenile dispersal. However, it is likely that the wildfire influenced these trends following the first removal because individuals moved away from burnt areas into unburnt habitat, such as within the removal site. These arguments together lend weight to the suggestion that not all replacement individuals were juveniles. The origins of the other potential replacements could be immigrating birds or non-calling individuals taking up territories, although evidence for this remains inconclusive.

Habitat for the eastern bristlebird within the study area is limited and, with a semi-flightless species, the dispersal of individuals is therefore limiting. This may provide a mechanism that can result in a non-territorial sector within a population if there are sufficient resources for the survival of individuals. A non-territorial sector of the population, along with juvenile recruitment and immigration, provides a range of mechanisms for the replacement of territory-holding individuals removed from the population.

For rare or cryptic species, often the only practical way of obtaining population estimates is through indirect survey techniques, such as surveying calling individuals. The present study highlighted the importance of taking care in interpreting such survey results because they represent only the numbers of calling individuals, presumably territory holders. Nonetheless, when monitoring populations of endangered species, the effective population size of territory holders or breeding individuals may be the most meaningful measure of population status.

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Table 1. Goodness-of-fit of Poisson distribution to the distribution of the nearest-neighbour distances

λ represents the average. *D* is the Kolmogorov–Smirnov one-sided test statistic. Significance values are also given. Removals occurred between each of the years. The results indicate that at both sites and in all years the distribution of the nearest-neighbour distances was significantly different from a random distribution

Site and year	λ (average)	*D*	*P*
Removal 2002	223	0.446	<0.0001
Removal 2003	163	0.342	0.0056
Removal 2004	218	0.545	<0.0001
Removal 2005	236	0.409	0.0005
Control 2002	184	0.466	<0.0001
Control 2003	176	0.357	0.0036
Control 2004	182	0.451	<0.0001
Control 2005	161	0.4	0.0007

Table 2. Comparisons of the distributions of the nearest-neighbour distances

Distributions are shown in Fig. 3. Because of the multiple comparisons conducted, a Bonferroni correction was applied, resulting in a corrected α value of 0.003 (1/16 × 0.05). Outcomes of differences in distributions are shown both with and without the correction applied. n1n2D, two-sample Kolmogorov–Smirnov statistic

Parameter	n1n2D	n1n2D$_{crit}$	*P*	Distributions (without correction)	Distributions (with correction)
Removal site					
2002 *v.* 2003	188	160	0.01	Different	Same
2002 *v.* 2004	72	140	0.71	Same	Same
2002 *v.* 2005	74	176	0.42	Same	Same
2003 *v.* 2004	114	133	0.13	Same	Same
2003 *v.* 2005	203	169	0.01	Different	Same
2004 *v.* 2005	76	150	0.73	Same	Same
Control site					
2002 *v.* 2003	50	133	0.96	Same	Same
2002 *v.* 2004	25	124	0.98	Same	Same
2002 *v.* 2005	56	140	0.57	Same	Same
2003 *v.* 2004	38	141	0.99	Same	Same
2003 *v.* 2005	129	160	0.17	Same	Same
2004 *v.* 2005	87	146	0.48	Same	Same
Removal *v.* control					
2002 *v.* 2002	116	140	0.07	Same	Same
2003 *v.* 2003	76	171	0.74	Same	Same
2004 *v.* 2004	86	124	0.15	Same	Same
2005 *v.* 2005	174	176	0.06	Same	Same

Table 3. Number of males and females removed and average wing lengths (± s.d.)

There was no change in the ratio of males to females caught by a consistent technique across the 3 years. The reduction in male wing lengths from 2003 to 2004 was significant. No other significant differences were detected amongst these measurements. Results from 42 individuals are presented because two translocated individuals were not measured

Year	Males	Wing length (mm)	Females	Wing length (mm)
2003	8	76.4 (1.8)	6	72.6 (3.2)
2004	10	73.5 (2.6)	10	70.8 (2)
2005	4	74 (1.8)	4	71.3 (1.3)

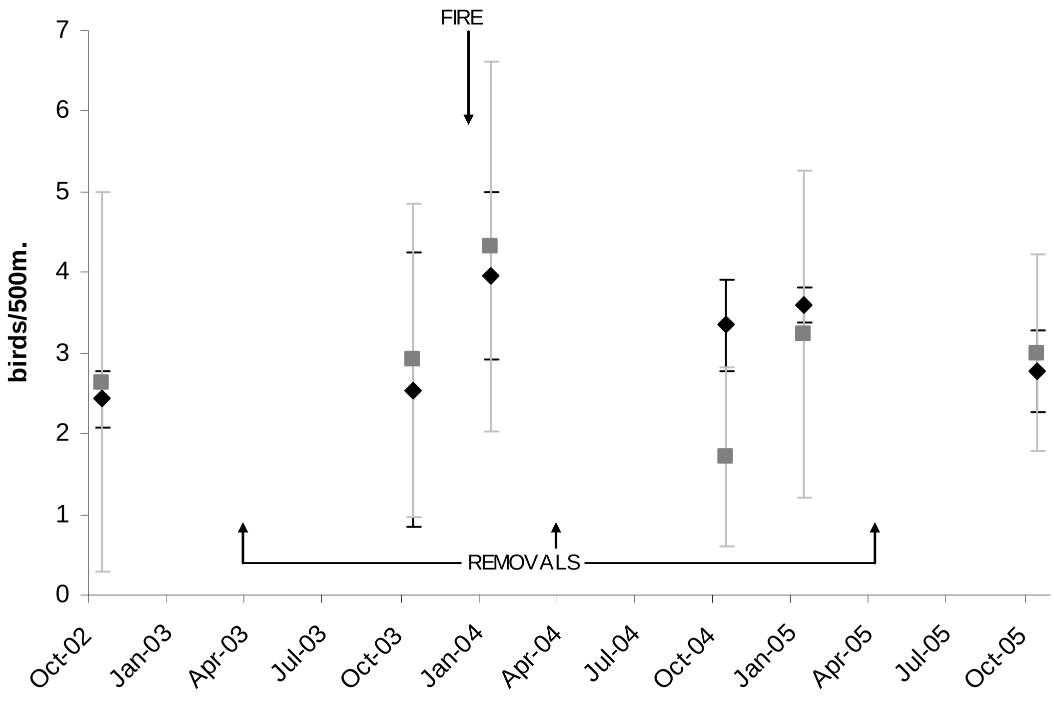

Fig. 1. Average number (± s.d.) of eastern bristlebirds surveyed across the 3 years of the study. Removal site (4 transects, ■), control site (2 transects, ◆). The removals occurred in autumn following the breeding season and surveys were carried out in spring (early in the breeding season) and in summer in 2004 and 2005, as a response to the fire that occurred in December 2003.

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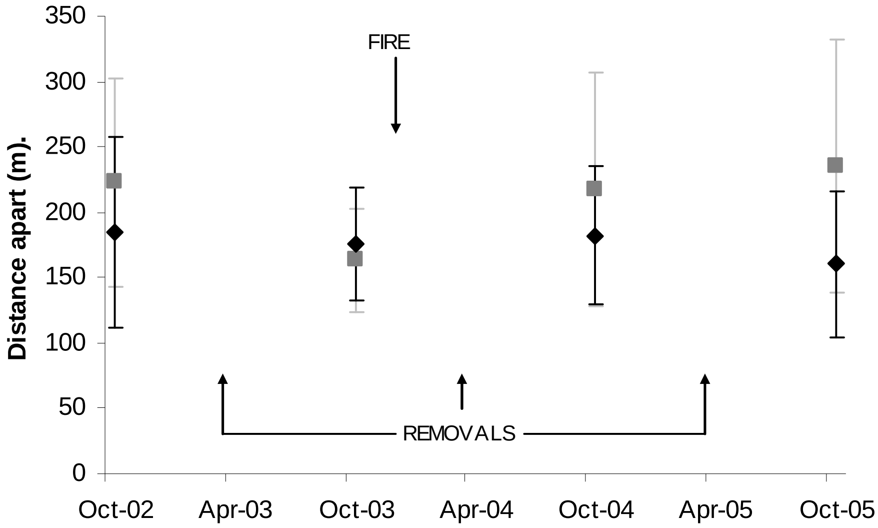

Fig. 2. Average nearest-neighbour distances (± s.d.) of eastern bristlebirds. Removal site (4 transects, ■), control site (2 transects, ◆). Data points represent pooled data across independent transects within a site. There were >15 and often >30 birds providing nearest-neighbour results for each transect.

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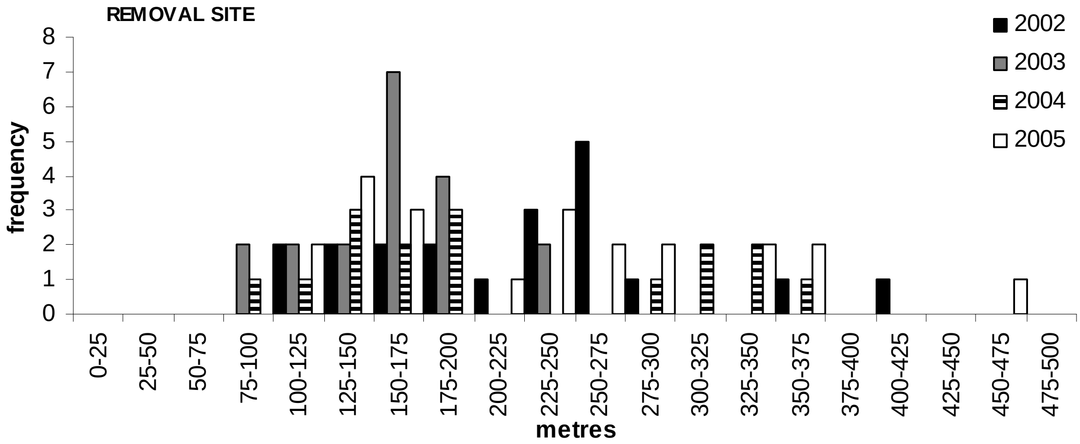

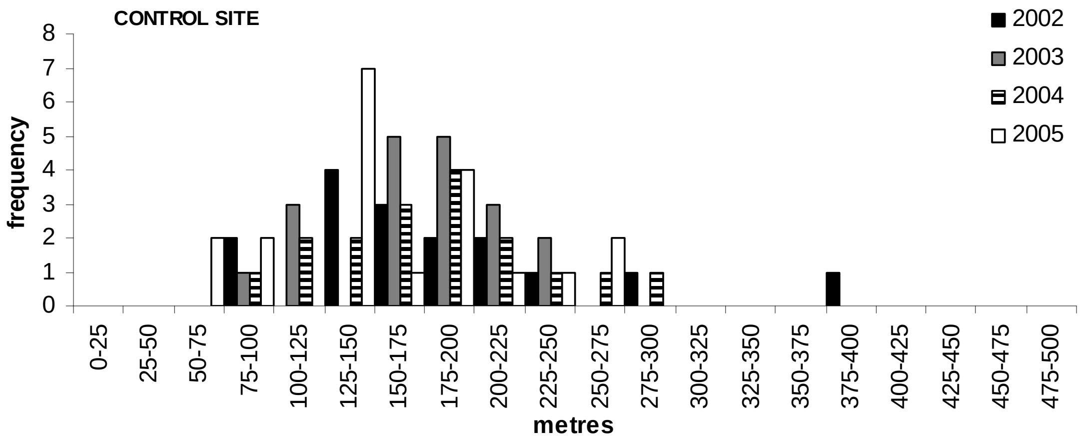

Fig. 3. Distribution of the nearest-neighbour distances of birds pooled across transects. Removals occurred between each of the years. The figure highlights the variation in the nearest-neighbour distances among years at the removal site and comparatively, the little variation in the nearest-neighbour distances within the control site.