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Habitat corridors and the conservation of small mammals in a fragmented forest environment

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Abstract

At Naringal in south-western Victoria, Australia, clearing of the original forest environment has created an agricultural landscape dominated by grazed pastures of introduced grasses. Remnant forest vegetation is restricted to small patches of less than 100 ha in size, that are loosely linked by narrow forested strips along road reserves and creeks. Six native and two introduced species of small terrestrial mammal (< 2 kg) occur within this environment. The native mammals, being dependent upon forest vegetation, were less tolerant to forest fragmentation than were the introduced species that also persist% farmland and farm buildings. The native mammals displayed an increasing frequency of occurrence in successively larger size-classes of forest patches. Those species with the greatest body-weight were the most vulnerable to habitat loss. All species of small mammal occurred in narrow habitat corridors of forest vegetation on roadsides. The resident status, seasonal variation in relative abundance, patterns of reproduction, and movements of each species were monitored in two habitat corridors during a 25-month trapping study. The corridors were found to facilitate continuity between otherwise-isolated populations of small mammals in this locality in two ways: firstly, by providing a pathway for the dispersal of single animals between patches; and secondly, by enabling gene flow through populations resident within the corridors. The small size of forest remnants at Naringal, and the vulnerability of species with low population sizes, emphasize the importance of preserving a mosaic of numerous habitat patches that together will support regional populations of sufficient size for longer-term persistence. The continuity between remnant habitats that is provided by a network of habitat corridors is an essential, and critical, component of this conservation strategy.

Introduction

For wildlife dependent upon forest environment's, fragmentation of the forest results in the formation of a mosaic of habitat patches surrounded by expanses of inhospitable terrain. Some species, notably birds, may readily traverse gaps between patches of suitable habitat; but for many fauna1 species, even small habitat discontinuities may pose a distributional barrier, or a severe limitation to free movement (Savidge 1973, Oxley *et al.* 1974, Barnett *et al.* 1978, Campbell 1981, Mader 1984).

The provision of habitat corridors – narrow connecting strips of favoured habitat – to link insular

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environments has been one of the most consistent recommendations proposed in recent strategies for the conservation of fauna in fragmented environments (Willis 1974, Diamond 1975, Wilson and Willis 1975, Friend 1980, Breckwoldt 1983, Recher *et al.* 1987). It is believed that the provision of corridors will facilitate the movement of fauna between populations that are otherwise isolated within disjunct patches. The resultant fauna1 interchange may increase the conservation value of the otherwise disjunct habitats in two ways: firstly, by reducing the vulnerability of insular populations to stochastic extinction from environmental disturbance, demographic fluctuation, or genetic deterioration; and secondly, by providing a means for recolonisation to occur should any local extinctions take place (Shaffer 1981, Simberloff and Cox 1987).

The occurrence of fauna in linear strips of habitat such as hedges, plantations, roadsides, and riparian strips, is well known (e.g., Lewis 1969, Pollard and Relton 1970, Eldridge 1971, Way 1977, Middleton 1980, Yahner 1983a,b, Adams 1984, Osborne 1984). However, little attention has been given to documenting the way in which such narrow strips may facilitate the dispersal of fauna through unfavourable environments, and to assessment of the potential conservation value that this would achieve (Wegner and Merriam 1979, Suckling 1984, Fahrig and Merriam 1985, Henderson *et al. 1985).*

At Naringal in south-western Victoria, Australia, clearing of the natural forest vegetation over the last 100 years has created an agricultural landscape dominated by pastures of introduced grasses. Forest vegetation is restricted to a mosaic of small patches of less than 90 ha in size, many of which are loosely linked by a network of narrow forested strips along road reserves and streams. In total, forest vegetation now occupies less than 10% of the study area (Bennett 1987a). Aspects of the insular biogeography of the mammalian fauna at this locality have been presented elsewhere (Bennett 1987b). This paper describes the status of small terrestrial mammals in the forest mosaic, and examines the role of narrow forested strips as habitat corridors in order to assess their contribution towards the conservation of small mammals in this region.

Methods

Study area

The study area at Naringal (38°24′S, 142°45′E) is situated on the coastal plains of south-western Victoria. This region experiences a temperate climate, with cool winter months and warm summers. Rainfall is reliable, and occurs throughout the year: the wettest months are during winter, particularly July and August. The mean annual rainfall is 890 mm. Forest vegetation is dominated by the trees *Eucalyptus obliqua* and *E. ovata,* and by *E. viminalis* in riparian situations and on more fertile soils. A dense understorey of sclerophyllous shrubs and ferns is usually present, except in those remnants that have been heavily grazed by domestic stock. Most patches of forest are less than five ha in size, but they range up to a maximum of 82 ha (Bennett 1987a). Forested strips on road reserves vary in width from less than 10 m on minor roads, to a maximum of 40 m along a main road.

Small mammals in remnant forest vegetation

The distribution and status of small mammals in remnant patches of forest were determined from surveys of the mammalian fauna in 39 patches ranging from 0.3 to 82 ha in size. The survey methods and the attributes of the forest patches surveyed have been described elsewhere (Bennett 1987a,b). An estimate of the mean density, and the range in density, of each species of small mammal in forest vegetation were calculated from captures on a trapping grid (RB grid, see below) that was operated on 17 occasions over a 25-month period (Bennett 1987a,b). Preliminary information on the occurrence of small mammals in forested vegetation on roadsides was obtained from surveys at 15 roadside sites (Bennett 1988).

Use of habitat corridors

The role of narrow strips of forested vegetation as habitat corridors was investigated by monitoring the resident status, population dynamics and movements of small mammals at two roadside sites. The CR (Cobden Road) trapping grid was a 0.25 km section of remnant forest vegetation, 30 m in width, adjacent to a main road, and located 0.6 km from the nearest forest patch (Fig. 1). The UR (Unmade Road) trapping grid was a 0.25 km section of forest vegetation, 20 m in width, occupying a fenced, but unused, road reserve extending for 1.1 km between two forest patches, termed RB and DB. The UR grid was separated from RB by a gravel road six metres in width.

At both CR and UR, a linear grid of 10 trapping stations spaced 24 m apart was established. Two traps, a folding aluminium trap and a wire-mesh cage trap, baited with a mixture of peanut butter, rolled oats and honey, were set at each station, the traps being positioned some 5 m apart perpendicular to the direction of the grid. The traps were not pre-baited. Trapping was carried out for four successive nights on 17 occasions, at approximately six-weekly intervals between March 1980 and March 1982. Each morning, captured animals were identified, weighed, and their sex and reproductive condition were noted. They were individually marked by toe-clipping or by inserting numbered metal tags in the ear.

Individuals were classed as ‘residents’ if they were recorded during more than one trapping session, ‘temporary residents’ if captured on two or more nights during a single trapping session, or ‘transients’ if captured once only.

Three types of movements of animals were recognised.

(i) Movements within a home range – local movements within an area defined as ‘the area over which an animal normally travels in pursuit of its routine activities’ (Jewel1 1966). Individuals were regarded as occupying a home range if they were present in the same locality for at least two adjacent trapping sessions.

(ii) Foray – a short-term movement involving an apparently marked displacement away from, and subsequent return to, a home-range area.

(iii) Dispersal – movement of an individual away from a home-range area, frequently resulting in the establishment of a new home range (Lidicker 1975).

Additional trapping in the vicinity of the UR grid provided useful information concerning the origin or destination of some animals recorded in the forested roadside strip. This additional trapping took the following forms.

(i) A trapping grid of nine rows of nine positions, with 24 m spacing between traps, was established in RB and trapped concurrently with the roadside grids (Fig. 1).

(ii) On three occasions (January 1981, August 1981 and May 1982), trapping was carried out along the full length (1.1 km) of the UR forested strip. Cage traps and folding aluminium traps were set alternately at intervals of 24-30 m, and were cleared each morning for three successive days.

(iii) On four occasions between April 1980 and January 1981, a trapping grid was operated for three successive nights in DB. The grid was situated directly adjacent to the UR forested strip (Fig. 1). Cage traps and folding traps, spaced at 24 m intervals, were positioned alternately in a pattern of five rows by eight columns.

(iv) Exploratory trapping, using lines of traps set for four nights, was carried out along the northern and eastern margins of RB and in roadside vegetation extending north and south from RB (see Fig. 1).

All animals captured during this additional trapping were examined and individually marked as described above.

Results

Status of small mammals in remnant vegetation

Eight species of small terrestrial mammal (body weight < 2 kg) were recorded from the study area (Table 1). Six species, the brown antechinus *Antechinus stuarti*, southern brown bandicoot *Isoodon obesulus*, long-nosed bandicoot *Perameles nasuta*, long-nosed potoroo *Potorous tridactylus*,

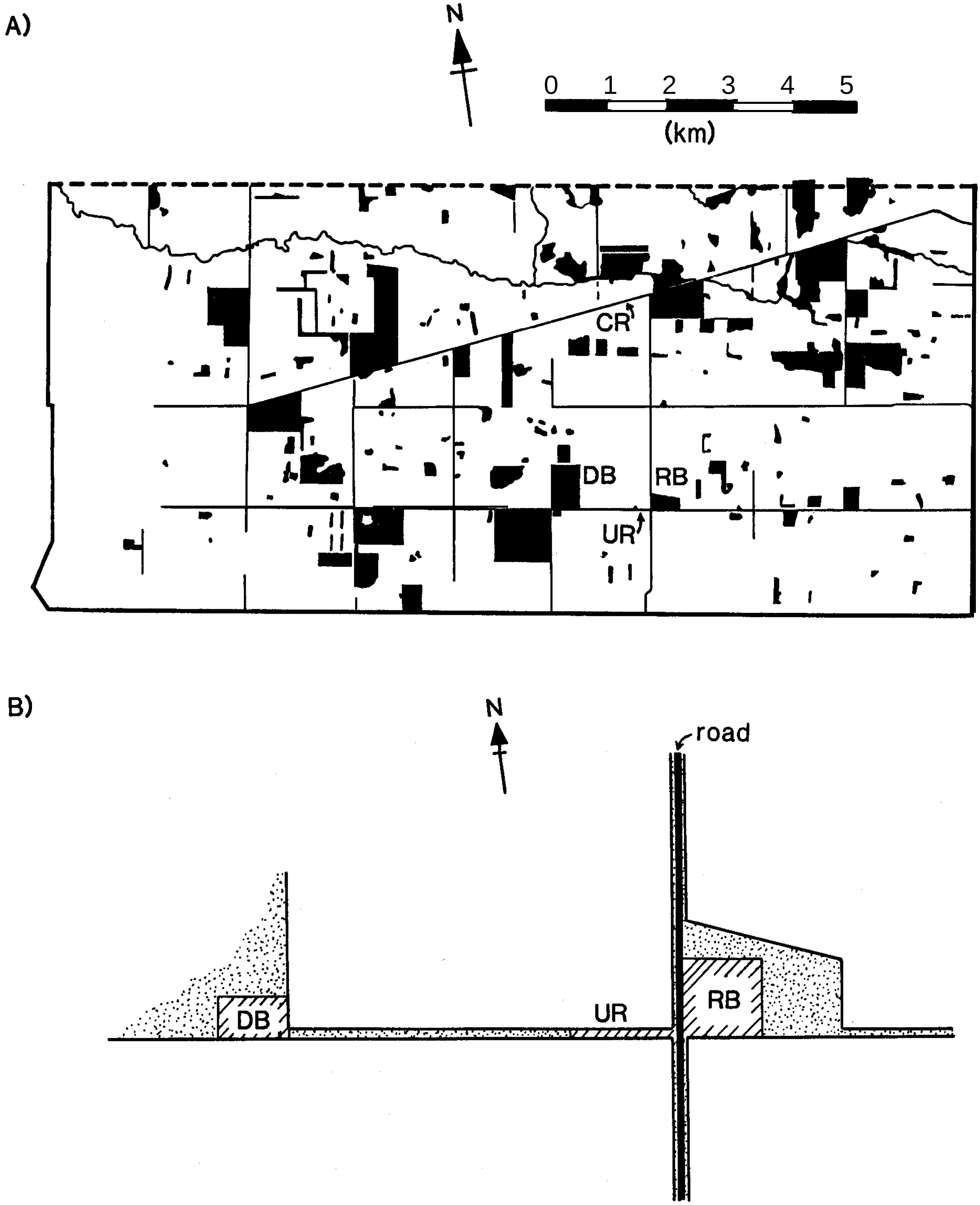

Fig. 1. a) Remnant forest vegetation (shaded) in part of the study area at Naringal, showing the location of the trapping grids: UR, CR, DB, and RB. Lines represent forested strips along roadsides.
b) Diagrammatic representation of the relationship between the UR corridor and the two forest patches (RB and DB) linked in this way. Diagonal shading represents trapping grids; other forest vegetation is stippled.

Table 1. Distribution and abundance of small terrestrial mammals in remnant forest vegetation at Naringal.

Species	Common name	Adult male body-weight (g)	Forest patches: Number of patches (n = 39)	Forest patches: Trapping success (captures1100 trap-nights) (n = 4946 trap-nights)	Roadside vegetation: Number of sites (n = 15)	Roadside vegetation: Trapping success (captures/100 trap-nights (n = 900 trap-nights)
Family Dasyuridae						
Antechinus stuartii	Brown antechinus	40	26	5.5	4	0.4
Family Peramelidae						
Isoodon obesulus	Southern brown bandicoot	1100	3	0.1	0	-
Perameles nasuta	Long-nosed bandicoot	1300	5	0.1	1	0.1
Family Potoroidae						
Potorous tridactylus	Long-nosed potoroo	850	17	2.3	4	1.2
Family Muridae						
Mus musculus	House mouse (*)	18	14	0.7	11	3.6
Rattus fuscipes	Bush rat	160	32	16.7	14	25.2
Rattus lutreolus	Swamp rat	130	6	0.2	3	4.3
Rattus rattus	Black rat (*)	200	3	0.1	1	0.4

(*) denotes introduced species.

bush rat *Rattus fuscipes*, and swamp rat *Rattus lutreolus*, are native mammals. They are primarily dependent on natural forest vegetation and were not observed or reported by local land owners as occurring in, or moving across, cleared farmland. Two introduced rodents, the house mouse *Mus musculus* and black rat *Rattus rattus*, have established feral populations in the area, but are not dependent upon forest vegetation; they also inhabit farmland and farm buildings.

The brown antechinus and the bush rat were common in remnant forest vegetation (Table 1), in patches as small as 1 ha, and in almost all patches larger than 3 ha (Table 2). The bush rat also was common in roadside forest strips (Table 1).

The long-nosed potoroo was relatively common in forest patches larger than 10 ha, but was seldom recorded in smaller patches, particularly those grazed by domestic stock. It also was trapped at four of the 15 roadside sites. In contrast, the southern brown bandicoot and long-nosed bandicoot were uncommon, both in forest remnants and in roadside vegetation (Table 1).

The swamp rat was recorded in six forest patches, generally at isolated sites where there was a moist understorey of sedges and other monocotyledons, and where trees were sparse or absent. The higher trapping success on roadsides than in forest patches (Table 1) reflects the greater availability of this favoured habitat in these narrow strips.

The house mouse was the most common introduced rodent (Table 1). Captures were often associated with disturbed vegetation or forest edges, and it was more frequently captured along roadsides than in forest patches (Table 1). The black rat was trapped in only three forest patches (two of which did not support native rodents) and at one roadside site.

The frequency of occurrence of native mammals increased with increasing size-class of forest patches (Table 2). Those species that occurred with a frequency > 50% were termed ‘core species’ (Bennett 1987b). They displayed a consistent nested pattern of occurrence, with those present in the smaller size-classes also being present as core species in successively larger size-classes (Table 2).

Table 2. Percentage occurrence of small terrestrial mammals in five size-classes of forest patch at Naringal. Core species (frequency of occurrence > 50%) are enclosed with blocks.

Size class (ha)	< 2	3-7	8-15	16-40	41-100
Number of patches	8		8	8	7
Bush rat	38	75	100	100	86
Brown antechinus	13	50	100	63 (10)	100 57 (86)
Long-nosed potoroo	0	13	50	63	100
House mouse	25	25	38	38	57
Swamp rat	0	13	13	25	29
Long-nosed bandicoot	0	13	13	0	43
Southern brown bandicoot	0	0	13	13	14
Black rat	13	25	0	0	0

Table 3. Tolerance of small terrestrial mammals to fragmentation of forest habitat at Naringal. Values < 1 .O indicate sensitivity to fragmenation; values > 1.0 indicate tolerance to fragmentation. Species are listed in descending order of values for the tolerance index.

Species	% occurrence in forest patches of: 2-10 ha (n = 13)	20-80 ha (n = 12)	Tolerance index % occurrence 2-10 ha / % occurrence 20-80 ha
Black rat	15	0	>> 1.0
House mouse	46	42	1.09
Bush rat	85	100	0.85
Brown antechinus	62	83	0.75
Swamp rat	15	25	0.60
Southern brown bandicoot	8	17	0.47
Long-nosed potoroo	31	92	0.34
Long-nosed bandicoot	8	25	0.32

Thus, species were added to the small mammal assemblage in a relatively predictable sequence.

As a simple means of quantifying the response of small mammals to habitat fragmentation, an index of tolerance to fragmentation was calculated, based upon the frequency of occurrence of each species in a group of small forest patches (2– 10 ha, n = 13), compared with their frequency of occurrence in a group of larger patches (20-80 ha, n = 12) (Table 3). Index values > 1.0 indicate tolerance to fragmentation while values < 1 .O indicate sensitivity to forest fragmentation. A consideration of these values suggests two trends that may underly the response of small mammals to fragmentation.

Firstly, the introduced mammals have a greater tolerance of fragmentation than do the native mammals. Both of the introduced species have tolerance indices greater than 1 .0; whereas all six native mammals have tolerance indices which are less than 1 .O (Table 3). This disparity is further illustrated by the relative contributions of introduced and native mammals to the assemblage of small mammals in small, compared with larger, forest patches. In patches ≤ 10 ha in size (n = 20), introduced mammals comprised a mean of 28% (range 0–100%) of the species complement; whereas in patches > 10 ha (n = 19), the mean proportion of introduced species was 9.3% (range 0–33%). These mean values are significantly different ($t = 2.24$, $p < 0.05$).

A second trend underlying the response of small mammals to forest fragmentation is the relationship between body-weight (here defined as body-weight of adult males) and the tolerance index

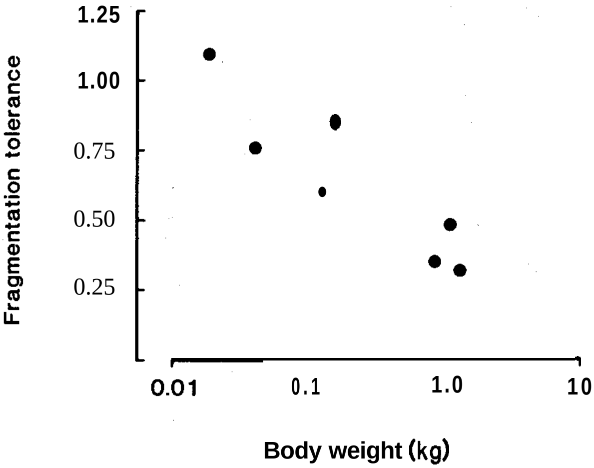

Fig. 2. Relationship between index of fragmentation tolerance and body-weight of small mammals at Naringal (r = 0.91; $p < 0.01$).

Table 4. Numbers of small mammals captured in two forested strips (CR and UR) on road reserves at Naringal, March 1980–March 1982. Numbers of captures are in parentheses.

Species	CR	UR
Brown antechinus	12 (29)	6 (16)
Southern brown bandicoot	2 (7)	3 (5)
Long-nosed bandicoot	2 (8)	3 (4)
Long-nosed potoroo	7 (97)	9 (52)
House mouse	16 (20)	13 (18)
Bush rat	62 (482)	37 (219)
Swamp rat	4 (5)	17 (84)
Total captures	648	398
Trap-nights	1360	1300

(Fig. 2). There is a significant negative relationship (r = 0.91, $p < 0.01$) between the tolerance index and log body-weight (Fig. 2). Species with small body size (e.g., brown antechinus, house mouse) have a higher tolerance to fragmentation than do larger animals (e.g., southern brown bandicoot, long-nosed potoroo). The inclusion of the black rat, for which a meaningful index was not available (Table 3), may slightly weaken this relationship.

The mean density (individuals per ha), together with the range in values of density from trapping sessions, for each species of native small mammal in the RB forest patch were as follows: brown antechinus 0.7 (0.2– 1.7); southern brown bandicoot 0.2 (o-0.4); long-nosed bandicoot 0.05 (o-0.3); long-nosed potoroo 2.3 (1.7-3.1); bush rat 6.0 (2.7-12.2); and swamp rat 0.05 (o-0.2). Clearly, the densities for some species may vary from these values depending upon the relative suitability of the habitat for each species (e.g., the mean value for the brown antechinus certainly underestimates its density in some other patches in the study area). However, these values provide a quantitative basis for estimating the sizes of populations of small mammals in hypothetical forest patches of differing size.

Use of habitat corridors by small mammals

Seven species of small mammal were captured at the trapping grids (UR and CR) in the corridors of forested vegetation on road reserves (Table 4). The black rat was trapped farther along the UR road reserve. The following summaries provide a basis for discussing the role of habitat corridors in the conservation of small mammals at this locality.

Brown antechinus

Small numbers were captured at both grids (Fig. 3), mostly during a single trapping session, and thus they were classed as transients or temporary residents (Table 5). Forest patches RB and DB had substantial breeding populations, but breeding in the habitat corridors, UR and CR, was limited.

Two individuals were recorded moving between the corridor and forest patch (Table 6). One was a dispersal movement; the other was an overnight foray of at least 0.3 km from UR to RB that included crossing a gravel road.

Southern brown bandicoot

Only five individuals were captured on the roadside grids (Fig. 3 and Table 5). The male of a resident breeding pair occupied a home range that encompassed parts of both RB and the UR corridor grid, and all but one of the recorded movements between forest patch and corridor (Table 6) were of this individual moving within its home range. The re-

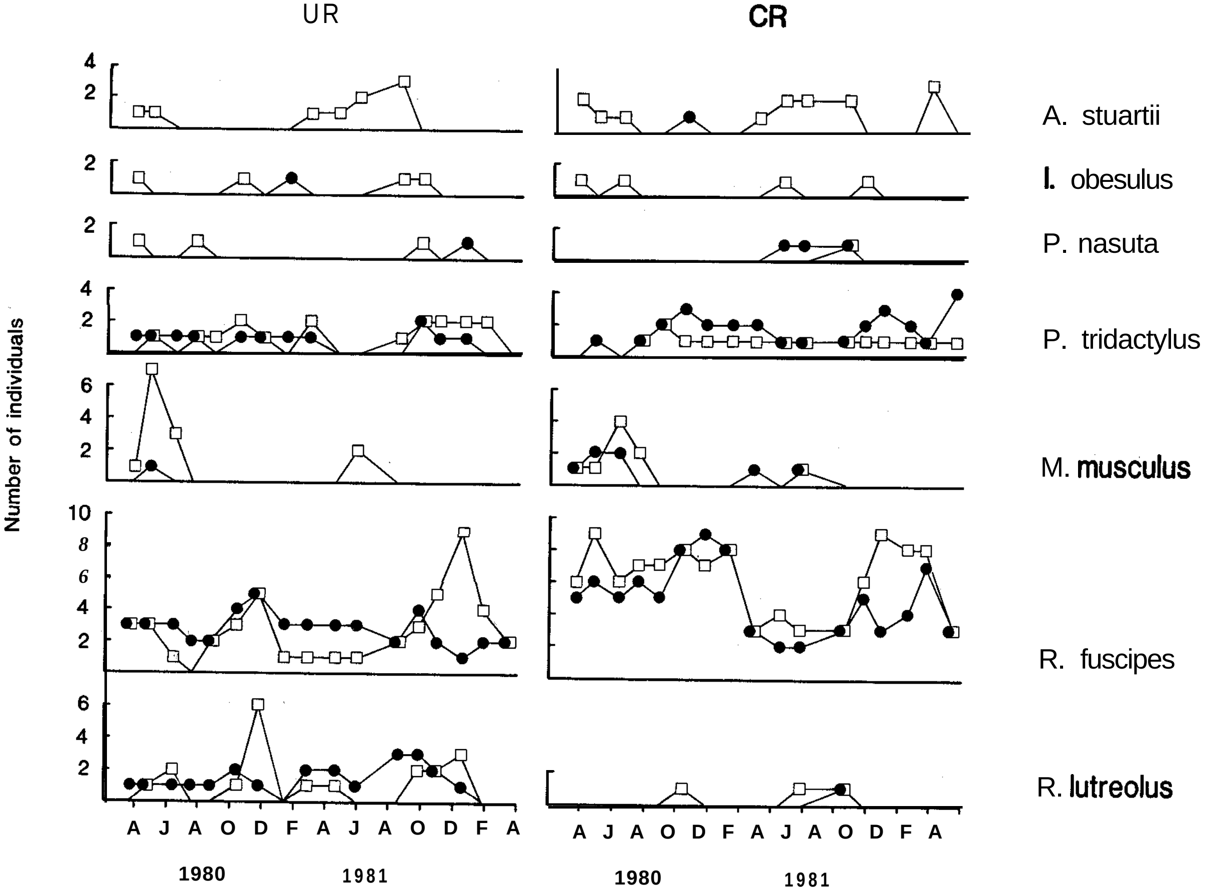

Fig. 3. Seasonal variation in the number of captures of small mammals on two trapping grids in forested corridors (UR and CR) at Naringal. (Open squares, males: closed circles, females).

maining movement was by a transient adult male that dispersed from UR to RB.

At CR (Table 5), one male was a transient, and the other was recorded twice, five months apart.

Long-nosed bandicoot

This species was recorded from the trapping grids only irregularly (Fig. 3). At CR, two individuals were trapped (Table 5); a young female that matured and bred there, and an adult male. Three individuals, including two transients, were trapped at UR (Table 5).

Long-nosed potoroo

The long-nosed potoroo was present in both of the forested strips throughout the study (Fig. 3), and most individuals were residents (Table 5). At both CR and UR, reproduction occurred throughout the year. Reproductively mature females that were captured during each trapping session (range 1 – 3 females per session), were each carrying a single pouch young, or young had recently left the pouch. Recruitment of young to the trappable population in the forested strips was low (only two independent juveniles were trapped). However, trappability is low and mortality is relatively high following pouch vacation (Bennett 1987a).

At UR, the home ranges of at least two individuals encompassed portions of both the corridor and the adjacent forest patch (RB). Eleven of the recorded movements between corridor and forest patches (Table 6) were by these two animals moving within their home ranges, at least twice involving an overnight movement (and road crossing) of up to

Table 5. Resident status of small mammals captured on two trapping grids (CR and UR) in forested road reserves at Naringal.

		CR grid				UR grid			
		Total number of individuals	Status			Total number of individuals	Status		
			Resident	Temporary	Transient		Resident	Temporary	Transient
Brown antechinus	M	11	2	4	5	6	1	1	4
	F	1	–	–	1	–	–	–	–
Southern brown bandicoot	M	2	1	–	1	2	1	–	1
	F	–	–	–	–	1	–	–	1
Long-nosed bandicoot	M	1	–	1	–	2	1	–	1
	F	1	1	–	–	1	–	–	1
Long-nosed potoroo	M	2	1	–	1	5	3	1	1
	F	5	3	1	1	4	3	–	1
House mouse	M	9		4	5	12	1	–	11
	F	7	–	–	7	1	–	–	1
Bush rat	M	39	25	8	6	26	15	6	5
	F	23	11	7	5	11	8	1	2
Swamp rat	M	3	–	1	2	13	5	4	4
	F	1	–	–	1	4	4	–	–

Table 6. Summary of recorded movements by small mammals between a forested strip (UR) and adjacent forested patches (RB and DB) at Naringal.

Species	Number of recorded movements				Number of individuals involved
	DB->UR	UR->RB	RB->UR	RB->DB	
Brown antechinus		2	1		2
Southern brown bandicoot		4	2		2
Long-nosed potoroo	2	10	9		7
Bush rat		5	6	1	7
Swamp rat			2		2

400 m. The other movements between forest patch and corridor included at least three instances of dispersal. Two involved adult males that were initially captured in DB and then moved more than a kilometre along the UR forested strip. One was captured as a transient on the UR grid and subsequently for at least nine months in an established home range in RB. The second individual, which occupied a home range in DB for at least 10 months, was captured in UR in August 1981, and then at the UR grid from September to December 1981.

House mouse

House mice were trapped in the corridors only in autumn and early winter (March- July) in each year (Fig. 3). There are no data on movements to or from either site. Sixteen individuals were captured at CR, all of which were trapped during only one session (Table 5). At UR, 12 individuals were captured during only one session and one was resident for two successive sessions.

Bush rat

This was the most abundant species in the corridors, with a resident population at each grid throughout the study period (Fig. 3, Table 5). Most animals at each grid were residents (58% of total individuals at CR, 62% at UR). Reproduction in the forested strips occurred between August and February. From August to November each year, reproductively-active males moved onto the grids and contributed to the peak in numbers during spring and early summer (Fig. 3). Young animals entered the trappable population between September and January.

The most notable dispersal movement was by a male first trapped as a sub-adult in RB, and then in DB forest patch some three months later, having travelled at least 1.1 km presumably along the UR forested strip. Most other movements between forest patch and corridor (Table 6) were forays of reproductively-active males during the breeding season. In one documented example, a male that was resident in RB for eight months was twice recorded moving between RB and UR during the breeding season, but later was trapped only in its former range in RB.

Swamp rat

The swamp rat was recorded at both forested strips (Fig. 3), but had a resident population only in a small patch of favoured micro-habitat at UR (Table 5). Reproduction was between October and December in each year, when numbers peaked due to an influx of reproductively-mature adult males, most of which were captured during only one session.

Two movements were recorded from forest patch to corridor (Table 6), both by reproductively-active males during the breeding season. One became resident at UR, but the other was present for only a single session.

Discussion

Small mammals in the agricultural landscape

Clearing and fragmentation of the natural forest vegetation at Naringal has had a marked impact on the small mammal fauna. The distributional patterns of all native species appear to be strongly influenced by the size of forest patches remaining in the landscape. Forest area was the best single predictor of the species richness of terrestrial mammals at Naringal (Bennett 1987b). However, multiple regression analysis incorporated three variables: the area and diversity of habitat; the extent of disturbance to forest vegetation from grazing by stock; and the time since isolation from contiguous forest, in an equation modelling species richness of the mammalian fauna in remnant patches of forest (Bennett 1987a,b).

The composition of assemblages of mammals in forest patches is also strongly influenced by forest area (Bennett 1987a,b). Smaller patches are occupied primarily by introduced species (house mouse, black rat) and by the most common and widespread native species (brown antechinus, bush rat) (Table 2). The least-common native species are most likely to occur in larger forest patches. Further, species with greater body-weight appear to be more vulnerable to habitat fragmentation than are smaller species (Fig. 2).

Estimates of population density in remnant forest vegetation clearly indicate that in many. patches only very small populations of most species are able to persist. No species is likely to have a population of more than 50 individuals in forest patches of 5 ha or less; and only one species, the bush rat, is likely to do so in patches of 20 ha in size. Importantly, 92% of forest patches in the study area are less than 20 ha in size (Bennett 1987a). Even in a hypothetical patch equal in size to the largest in the study area (82 ha), only three (brown antechinus, long-nosed potoroo, bush rat) of the six native species are likely to be represented by populations of more than 50 individuals. Of particular concern is the very small size of expected populations of the two bandicoots.

The minimum sizes of populations that are necessary for the long-term conservation of wildlife species remain an unresolved issue (Shaffer 1981, Shaffer and Samson 1985, Soulé and Simberloff 1986). However, it is clear that in this area, single remnants of forest are inadequate for the maintenance of populations of sufficient size to maintain long-term viability. Further, the relatively small size of remnants leaves them vulnerable to other sources of disturbance. Land owners continue to clear forests on their properties; and, in 1983, a wildfire completely burned all vegetation in most of the patches (including the largest), and decimated fauna1 populations (Bennett, unpublished). Effective conservation of fauna in such fragmented natural environments requires the adoption of a regional perspective, and must be based around the preservation of a mosaic of numerous habitat patches that together will support substantial regional populations (Henderson *et al.* 1985, Bennett 1987a). In such situations, the degree of connectivity between patches, and thus the level of continuity between populations in each patch, becomes a critical component of the strategy (Merriam 1984, Forman and Godron 1986).

Use of habitat corridors

This study provides evidence that corridors of forested vegetation along road reserves at Naringal facilitate continuity between populations of small mammals in forest patches in two ways. Firstly, individuals may traverse the corridors between forest patches either by a single direct movement, or by a series of movements punctuated by one or more periods of temporary residency in the corridor. Secondly, the presence of resident animals within the corridor, combined with movements to and from this resident group, provides the opportunity for gene flow between populations in habitats that are linked in this way. Such gene flow may result from a series of movements within a short period of time (e.g., within a breeding season), or it may occur over several generations.

There were two instances in which animals were recorded as moving the full 1.1 km length between the two forest patches, RB and DB. These were an adult male long-nosed potoroo, and a sub-adult male bush rat. Other lengthy traverses are also likely to have occurred at both UR and CR, as shown by the numerous animals that were recorded either as temporary residents or transients (Table 5). For the southern brown bandicoot and long-nosed bandicoot, movements between forest patches by single animals appears to be the most important use of the corridor. Most of these individuals (6/10) were captured during only one session, and were males or sub-adult females that were presumed to be dispersing between forest patches.

The effectiveness of corridors for dispersal by single animals depends upon the distance to be traversed. In this study area, most forest patches are separated from other patches by less than a kilometer, and it is unlikely that this distance would preclude movements by small mammals if suitable habitat is available to pass through. No attempt was made in this study to record'possible movements of native small mammals across cleared farmland, because current knowledge of the micro-habitat preferences and resource requirements of these species (e.g., Braithwaite *et al.* 1978, Gullan and Robinson 1980, Seebeck 1981, Bennett 1987a) strongly indicate that closely-grazed pastures of exotic grasses are an alien environment. Further, many hours of both diurnal and nocturnal observations during surveys in this area (Bennett 1987a), provided no evidence of these species in farmland. However, farmland is not an absolute barrier to movements, and where forest patches are close, there is the potential for animals to disperse without requiring habitat corridors.

With increasing distance between forested remnants, and a corresponding decline in the likelihood of single animals traversing the intervening distance, gene flow through a population resident within a habitat corridor will be the most effective way that such corridors may function. In this study, the long-nosed potoroo and the bush rat were recorded as resident and breeding in both corridors. The brown antechinus also had small breeding populations in both corridors, and the swamp rat was resident and breeding at one site (UR). Individuals of the southern brown bandicoot, long-nosed bandicoot, and house mouse were resident in the corridors; but except for a single long-nosed bandicoot, breeding was not recorded.

There is ample evidence that animals moved readily between the corridor (UR) and the adjacent forest patches (DB and RB) (Table 6). In at least four instances, animals occupied home ranges that apparently encompassed portions of both the corridor and the adjacent forest patch, thus emphasising the continuity between these forested areas.

Dispersal movements between forest patch and corridor were recorded for the brown antechinus, the long-nosed potoroo, and both native rodents (Table 6). Forays by male bush rats were mainly during the breeding season; at this time males range widely from a home range occupied over the previous winter months (Lunney 1983). Movements by swamp rats follow a similar pattern (Braithwaite and Lee 1979). Forays by the brown antechinus and long-nosed potoroo were also tentatively recognized. Assuming that dispersing individuals and reproductively mature animals that made forays during the breeding season successfully participated in reproduction, the net result of these movements is an effective gene flow between populations in RB and DB, through the population resident in' the corridor.

Habitat corridors and conservation strategy

Habitat corridors have received widespread acceptance as a simple, intuitively appealing, and practical conservation measure, and they are now regularly incorporated into many land-use plans and conservation strategies. However, evidence for the effectiveness of corridors in promoting continuity between isolated habitats is limited, and is largely restricted to studies involving small, closely-spaced patches of habitat in agricultural landscapes (Saunders 1980, Merriam 1984, Suckling 1984, Henderson *et al.* 1985, Fahrig and Merriam 1985, this study). Little is known, for example, of the effectiveness of habitat corridors on a broader scale, where links between habitat components may extend for 5–50 km, or more.

Recently, several authors (Frankel and Soulé 1981, Ambuel and Temple 1983, Simberloff and Cox 1987) have cautioned against uncritical acceptance of the value of corridors. In addition to the positive benefits of corridors, there may also be costs that need to be considered (Simberloff and Cox 1987). These disadvantages include the possibility that increased immigration through corridors may facilitate the spread of fire and other disturbances; that there may be increased exposure of wildlife to hunters, poachers, and other predators; and that particular habitats (e.g., riparian strips) selected as corridors may not be suitable for certain species (Noss 1987).

These are pertinent comments and warrant further consideration. At Naringal, for example, the effectiveness of roadside vegetation as a corridor may be limited by at least two factors. Firstly, predation of small mammals on road reserves is potentially greater than in continuous forest due to the relative abundance of introduced feral predators (cats *Felis catus*, and foxes *Vulpes vulpes)* in this habitat, and to the presence of vehicular traffic. Secondly, the narrow width of the vegetation on many reserves renders it vulnerable to invasion by weeds and to other disturbance; and this, in turn, affects the food resources and micro-habitats of small mammals. Further, the perception by some in the community that roadside vegetation is an unacceptable fire hazard, and that it harbours vermin (e.g., rabbits *Oryctolagus cuniculus*), poses an additional challenge to land management.

In view of the importance of habitat corridors in the conservation of fauna in fragmented environments, there is an urgent need for further research to investigate and document the effectiveness of habitat corridors for a wide range of taxa, and over a range of distances. In particular, research that is oriented towards determining the optimum dimensions of corridors to support resident populations of a range of wildlife species, while also maintaining the integrity of the corridor habitat, will be of immediate value to wildlife managers.

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