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Influence of food availability, predator density and forest fragmentation on nest survival of New Zealand robins

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ARTICLE INFO

Article history:
Received 24 September 2007
Received in revised form
3 December 2007
Accepted 7 December 2007
Available online 30 January 2008

Keywords:
Petroica
North Island robin
Rattus rattus
Connectivity
Livestock grazing
Pitfall traps

ABSTRACT

The decline of avian populations in fragmented landscapes is often attributed to a decrease in nest survival rates for species breeding within these habitats. We tested whether fragment size and connectivity, livestock grazing, predator density or invertebrate biomass were correlated with nest survival rates for an endemic New Zealand species, the North Island robin (*Petroica longipes*). Across three breeding seasons (2002–2005) daily nest survival rate for the 203 robin nests monitored in 15 forest fragments was 0.315 (SE 0.003), with nest survival rates increasing with invertebrate biomass (indexed with pitfall traps) and marginally decreasing with fragment size. Footprint tracking rates for exotic ship rats (*Rattus rattus*), which are likely to be the key nest predator, varied greatly among fragments, but were not a useful predictor of nest survival. We found no relationship between the number of fledglings per successful nesting attempt and invertebrate biomass. We conclude that fragment size and connectivity does not appear to be negatively influencing robin nest survival, potentially because of the already high impact that mammalian nest predators have in this unique system.

1. Introduction

Habitat fragmentation converts areas of continuous habitat into small, isolated remnants. Together with the total loss of habitat, this land transformation is widely inferred as a primary cause of recent biodiversity loss worldwide (Vitousek et al., 1997). For some species, reduction in the size and connectivity of fragments can decrease the overall quality of the remaining habitat (Saunders et al., 1991), as well as increasing local extinction rates by altering the metapopulation dynamics (Hanski and Gaggiotti, 2004). Reduced food availability, increased access by predators, and increased grazing pressure by livestock may affect habitat quality, all of which may reduce survival and reproductive rates of the native species occupying these modified habitats. Concern about the decline of avian populations in fragmented forest systems has led to studies attempting to determine effects of fragmentation on adult survival, fecundity and nest survival (Lampila et al., 2005).

A key finding in many fragmentation studies has been the reduction in nest survival in small forest fragments due to an increased rate of nest predation (Stephens et al., 2003). While increased rates of nest predation are generally attributed to increased density and/or activity of certain nest predators (Gates and Gysel, 1978), there have been few attempts to confirm this assertion via direct data on nest predators (Chalfoun et al., 2002). The few studies conducted show that the response of nest predators to fragmentation depends on the taxon, spatial scale, region and habitat matrix considered (Chalfoun et al., 2002).

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0006-3207/$ - see front matter
doi:10.1016/j.biocon.2007.12.007

Evidence has emerged that forest fragmentation may also affect avian food availability (Robinson, 1998), with detectable food shortages observed in small habitat fragments (Burke and Nol, 1998; Zanette, 2000; Luck, 2002, 2003). Food availability, like nest predation, is known to be an important factor affecting reproductive success of birds, with higher reproductive output generally associated with years (or areas) with greater food abundance (Newton, 1998; Crawford et al., 2006). Nestling starvation during adverse weather conditions has been associated with decreased invertebrate densities (Högstedt, 1981), as has the number of fledglings per successful nest (Strong et al., 2004). As nest survival is one of the key parameters affecting reproductive output, a reduction in nest survival caused by low food availability, higher nest predation or the synergistic effect of both (Zanette et al., 2003) would obviously be detrimental for species' persistence in fragmented landscapes.

The study of the effects of habitat fragmentation on nest survival is not evenly distributed across geographic regions or habitat types, as the vast majority of the literature focuses on Nearctic and Palearctic passerine migrants from boreal and temperate regions (Stephens et al., 2003; Lampila et al., 2005). The response of nest predators to fragmentation has also been studied mainly in North America (Chalfoun et al., 2002). To understand the potentially different mechanisms driving reduced nest survival in forest fragments, studies should expand across different systems.

No information exists on the effects of forest fragmentation on nest survival in New Zealand, even though extensive fragmentation has taken place over the last 150 years. Exotic mammalian predators have caused many extinctions and severe declines among New Zealand's endemic avifauna (Duncan and Blackburn, 2004), and are believed to be the main cause of ongoing population declines of several species (McLennan et al., 1996; O'Donnell, 1996; Moorhouse et al., 2003). Consequently, conservation management and research focuses heavily on the control or eradication of these exotic predators. However, it is currently unknown whether fragmentation has played a role in these birds' declines, and whether fragmentation interacts with predators or food availability.

We address these gaps in the knowledge of habitat fragmentation by examining nest survival of an endemic New Zealand passerine breeding in a fragmented podocarp–broadleaf forest. Using recently developed methodology to evaluate avian nest survival data (Shaffer, 2004), we assess whether nest survival rates vary with size and connectivity of forest fragments, and whether such variation is attributable to effects of invertebrate biomass, predator activity, and/or grazing pressure. We also assess whether invertebrate biomass affects the number of fledglings produced per successful nesting attempt.

2. Methods

2.1. *Species and study site*

The North Island robin (*Petroica longipes*) is a small (26–32 g) passerine belonging to the endemic Australo-Papuan Family Petroicidae. The North Island robin and South Island robin (*P. australis*) were formerly considered to be subspecies of "New Zealand robin" but the two subspecies were recently separated based on morphological and molecular differences (Holdaway et al., 2001; Miller and Lambert, 2006). North Island robins are a good model species to test for the effects of habitat fragmentation in New Zealand because: (a) Petroicidae species in Australia have been shown to be area sensitive (Major et al., 1999a, 2001; Zanette, 2000; Cousin, 2004; Watson et al., 2005); (b) they have significantly declined since Polynesian and European colonisation (Oliver, 1955); (c) they are known to be strongly negatively affected by exotic mammalian predators (Powlesland et al., 1999; Armstrong et al., 2006); but (d) they still coexist with mammalian predators in the central North Island unlike many other New Zealand birds that are now restricted to predator-free offshore islands.

North Island robins are socially and genetically monogamous, with pair bonds usually retained throughout the breeding season and subsequent years until the death of the partner (Ardern et al., 1997). Females are multi-brooded and typically incubate clutches of 2–3 eggs for 19 days and brood nestlings for 21 days (Powlesland et al., 2000). Males do not incubate or brood, but bring food to the female and nestlings.

We initially searched for robins in 55 podocarp–broadleaf forest fragments over a 14,000 ha landscape (Fig. 1, 175° 22′E, 38° 32′S) near the township of Benneydale in the central North Island, New Zealand. Agricultural land, used for sheep and cattle grazing, dominated the landscape with large tracts of exotic plantations (*Pinus radiata*) to the south and east. We found robins in 13 forest fragments <150 ha, and selected these for study along with two larger fragments (Table 1). We calculated an index of functional patch connectivity (IFPC; Table 1) for each fragment based on its functional connectivity to other fragments within a 3-km radius of its perimeter. The IFPC for any fragment is given by

$$\sum_i \frac{A_i}{\min \sum_j c_j d_{i,j}}$$

where A_i is the area (ha) of each of i native fragments within the 3-km radius (excluding the focal patch), $d_{i,j}$ is the distance travelled over each of j vegetation types to reach fragment i, and c_j represents the cost perceived by the bird of moving through each vegetation type. We recognised four vegetation types (native forest, pine forest, woody vegetation <2 m high, and pasture), and assumed that the relative costs of moving through these substrates were 1, 2, 3 and 10, respectively based on observations of radio-tracked juvenile robins. The equation assumes that the "least cost path" (Bunn et al., 2000; Adriaensen et al., 2003) is taken, minimizing the distance crossed over pasture, and this path was determined using an iterative routine (Cost Distance tool) from ArcGIS 9.0 (ESRI, Redlands, California, USA). A tool for calculating IFPC and its description are available at: http://www.massey.ac.nz/~yrichard. The 3-km radius corresponds to the median dispersal distance achieved by juvenile robins (Richard, 2007). This index differs from conventional measurements of fragment connectivity that only consider the straight line distance to the nearest forest area of a particular minimum size and ignore the matrix features that impede or facilitate individual movements (Watson et al., 2005).