Biological Conservation 227 (2018) 343–351

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Spatially and temporally targeted suppression of despotic noisy miners has conservation benefits for highly mobile and threatened woodland birds

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ARTICLE INFO

Keywords:
Precautionary principle
Adaptive management
Threatened species
Population monitoring
Invasive species
Australia

ABSTRACT

Interactive effects of habitat loss and interspecific competition are major threats to global biodiversity. Managing despotic competitors in modified landscapes is a conservation priority, but implementing actions to benefit rare and highly mobile species is challenging. In Australia, overabundance of hyperaggressive noisy miners following woodland fragmentation and degradation is a key threatening process given their impact on songbirds including the nomadic, critically endangered regent honeyeater. Recent studies have found rapid noisy miner recolonization following their experimental removal, questioning the efficacy of miner removal as a conservation measure. We estimated the relative habitat saturation of noisy miners at a hotspot of threatened bird diversity. We then experimentally removed 350 noisy miners and assessed the effect of this removal on subsequent noisy miner abundance, relative to a control area. We monitored the occurrence of noisy miners near regent honeyeater nests and modelled the effect of noisy miner removal on songbird populations. Noisy miner removal significantly decreased noisy miner abundance throughout the breeding season, when 15–18 regent honeyeaters nested in the miner removal area. Songbird abundance and species richness increased significantly in the miner removal area, relative to the control area. We provide a rare example of how spatially and temporally targeted preventative action can reduce threats for nomadic and highly threatened species during breeding and prevent ongoing avian diversity loss more broadly.

1. Introduction

Interactive effects of habitat loss and interspecific competition are major and ongoing threats to global biodiversity (Byers et al., 2002; Didham et al., 2007). Habitat loss increases niche overlap and subsequent interspecific competition for remaining resources (Scheele et al., 2017). Increases in the abundance of territorial and disruptive generalists or edge specialists (hereafter 'despotic generalists') following habitat loss and fragmentation can cause biotic homogenisation through competitive exclusion of smaller, rare or mobile species from habitat in which they may otherwise persist (Ford et al., 2001; Robertson et al., 2013).

Following habitat modification, the length of time that interspecific competition can affect population trends of co-occurring species is unclear (Didham et al., 2007). This uncertainly is likely because population trends of competing species can change for decades following habitat modification (Didham et al., 2007). In many modified environments, population changes due to interspecific competition are therefore likely to be ongoing (Sanderson et al., 2006). Even less clear are the circumstances under which interventions to suppress populations of despotic generalists can be successful and cost-effective (Grey et al., 1998; Davitt et al., 2018).

Highly mobile (i.e. nomadic, semi-nomadic or migratory) species pose unique challenges for conservation because predicting where and when to implement applied conservation action is difficult (Runge et al., 2014). Competitor suppression may represent wasted investment if mobile species do not subsequently occupy that location, or if competitors recolonise shortly afterwards (Stojanovic et al., 2014). Meanwhile, at locations mobile species do occupy, threats from despotic competitors continue unabated. Difficulties predicting when and where mobile species will settle, and associated risk of wasting conservation resources means these species are under-conserved and disproportionately threatened globally (Webb et al., 2014; Cottee-Jones et al., 2015). Nonetheless, competitor suppression is most likely to benefit threatened, mobile species when preventative action is taken at times and locations when both species are present, but before the

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https://doi.org/10.1016/j.biocon.2018.10.006
Received 6 June 2018; Received in revised form 20 September 2018; Accepted 2 October 2018
Available online 05 October 2018

negative impacts of despotic generalists have fully manifested (Cooney, 2004; Crates et al., 2017a; Leung et al., 2002; Pluess et al., 2012).

In southeast Australia, widespread and ongoing vegetation clearance has led to extreme fragmentation of lowland woodland communities (Bradshaw, 2012; Tulloch et al., 2016). The noisy miner *Manorina melanocephala*, a medium sized (~63 g), native generalist honeyeater occupies sparsely-vegetated habitats and has benefitted greatly from habitat fragmentation and degradation (Maron, 2007; Piper and Catterall, 2003). Noisy miners are sedentary cooperative breeders and establish colonies that aggressively exclude smaller-bodied songbirds (passerines, order Passeriformes) from potential breeding habitat (Piper and Catterall, 2003). The presence of even small numbers of noisy miners during breeding risks decreasing reproduction of co-occurring species through nest destruction or disturbance (Thomson et al., 2015; Crates et al., in press). Severe woodland clearance and noisy miner invasion interact to homogenise bird communities via population declines of threatened woodland specialists (Ford et al., 2001; Mac Nally et al., 2012). The noisy miner is therefore listed as a key threatening process under biodiversity legislation and development of methods to reduce their impact on avian diversity is an urgent conservation priority (Threatened Species Scientific Committee, 2014).

Recent studies have experimentally removed noisy miners to assess the viability of culling as an avian conservation measure (Davitt et al., 2018; Beggs et al., in review). A common result of these studies is rapid noisy miner recolonization, often within days, with minimal decrease in miner abundance or increase in songbird abundance (Davitt et al., 2018; Beggs et al., in review). Since earlier studies found songbird populations increased following experimental miner removal (Grey et al., 1998), the factors determining the success of noisy miner removal for avian conservation remain unclear. Here we build on recent work by experimentally removing noisy miners from a known breeding site of the critically endangered and nomadic regent honeyeater *Anthochaera phrygia*. Regent honeyeaters (contemporary population 350–500, Kvistad et al., 2015) are disproportionately impacted by the ongoing spread of noisy miners because lowland woodland clearance has led to extensive overlap between the two species' remaining breeding habitat throughout their 600,000 km^2 range (Commonwealth of Australia, 2016; Ford et al., 2001; Ford, 2011). Where they co-occur, regent honeyeaters compete with noisy miners and other large honeyeater species for nectar and invertebrates (Ford, 1979). Increases in noisy miner abundance over the past two decades may have contributed to a decrease in regent honeyeater nesting success over this period (Crates et al., in press). Challenges associated with the regent honeyeater's small population size, vast range and irregular breeding locations have constrained attempts to implement targeted actions such as competitor suppression to aid population recovery.

We aimed to assess the effectiveness of noisy miner suppression as a means of; 1) reducing noisy miner abundance; 2) preventing and reducing competition from co-occurrence of noisy miners and regent honeyeaters during nesting; and 3) increasing songbird abundance and species richness. Based on the absence of potential source habitats for noisy miners nearby, we predicted that noisy miner removal would lead to a sustained reduction in their abundance, which would prevent their co-occurrence with any breeding regent honeyeaters. We also predicted that songbird diversity and species richness would increase following miner removal, relative to the control area.

2. Methods

2.1. Study location

The study was conducted in woodland surrounding a 7.75 km stretch of the Goulburn River in the Greater Blue Mountains, New South Wales, Australia (Fig. 1). This location is typical of remaining regent honeyeater breeding habitat, with largely cleared agricultural river flats varying in width from 5 to 400 m. Regent honeyeaters breed on lower slopes and valley floors with remnant patches of box-gum *Eucalyptus* spp. woodland and riparian gallery forest (Crates et al., 2017b; Crates et al., in press). We considered that all potential regent honeyeater breeding habitat was also potential habitat for noisy miners, as these vegetation communities were never > 200 m from a habitat edge (Piper and Catterall, 2003). Surrounding the cleared river flats is largely continuous dry shrubby woodland. In contrast to many areas within the regent honeyeater's range, including the study areas of Davitt et al. (2018) and Beggs et al. (in review), the heavily-forested matrix surrounding the study location is unsuitable for noisy miners, which are rare in the surrounding area (Maron, 2007, Fig. 1). In November 2016, a range-wide regent honeyeater monitoring program detected 4 regent honeyeater pairs breeding within the study location, all of which were frequently observed aggressively defending nests from co-occurring noisy miners (Crates et al., in press).

2.2. Pre-removal bird surveys

During the week commencing 1st August 2017, 189 monitoring sites were established within the treatment and control areas (145 treatment sites and 44 sites control sites, Fig. 1). Although multiple treatment and control areas would have been desirable, the experimental design was determined by external factors including cost, the number of miners that could be removed under licence and the known distribution of breeding regent honeyeaters. Each monitoring site was a point count of the surrounding 50 m radius centred on a fixed location. Monitoring sites were spaced at least 140 m apart, firstly to account for fine-scale variation in noisy miner occupancy, habitat characteristics and associated effects on songbirds (Piper and Catterall, 2003) and second to maximise detection of regent honeyeaters given their small breeding territories (Crates et al., 2017b). During each site visit, maximum counts of noisy miners and other songbirds within each site during a 5-minute survey period were recorded. Adaptive sampling was used to add sites adjacent to those occupied by noisy miners, oriented towards the woodland interior until miners were no longer detected (Smith et al., 2004; Maron, 2007). Each site was visited twice during a 5-day period from 3–7th August 2017, prior to the removal of noisy miners. Detection probability of noisy miners (p = 0.82) and other songbirds including the regent honeyeater (p = 0.59) using this survey design have been shown previously to be high (Crates et al., 2017b).

2.3. Noisy miner removal

Noisy miners were removed from 430 ha of woodland within the treatment area by two licenced marksmen over a 5-day period commencing 8th August 2017. This date was specifically chosen to be as close as possible to, but before the potential arrival of any regent honeyeaters to the location (Ford et al., 1993; Crates et al., 2017b). Noisy miner calls were broadcast (Pizzey and Knight, 2014) from portable speakers to attract miners, which were subsequently removed from the treatment area using 2 × 12-gauge shotguns and size 8 shot. The treatment area was divided into 4 sections of approximately equal size and miners were removed via a daily unstructured search of each section. On the fifth day, a follow-up sweep of the entire treatment area was conducted until dusk to maximise the number of miners removed.

2.4. Post-removal bird surveys

Repeat site visits were made to all monitoring sites over 3 sets of 6 day periods, commencing 2 days, 1 month and 3 months after miner removal. As per pre-removal surveys, maximum counts of all songbirds detected during each repeat 5-min site visit were recorded.

2.5. Regent honeyeater monitoring

Nesting activity of all regent honeyeaters detected (visibly or