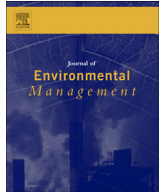




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Research article

Can hedgerow management mitigate the impacts of predation on songbird nest survival?

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ABSTRACT

Nest predators can have significant impacts on songbird reproductive success. These impacts may be amplified by habitat simplification and here we test whether sympathetic management of farmland hedgerows can reduce nest depredation, especially by corvids. We test whether songbirds select nest sites according to structural features of hedgerows (including nest visibility and accessibility), and whether these features influence nest predation risk. Songbirds selected nesting sites affording higher vegetation cover above the nest, increased visibility on the nest-side of the hedgerow and reduced visibility on the far side of the hedge. Nest survival was unrelated to corvid abundance and only weakly related (at the egg stage) to corvid nest proximity. Nest survival at the chick stage was higher where vegetation structure restricted access to corvid-sized predators (averaging 0.78 vs. 0.53), and at nests close to potential vantage points. Overall nest survival was sensitive to hedgerow structure (accessibility) particularly at low exposure to corvid predation, while the overall impact of corvid exposure was dependent on the relationship involving proximity to vantage points. Nest survival over the chick stage was much higher (0.67) in stock-proof, trimmed and mechanically cut hedgerows, (which tended to provide lower side visibility and accessibility) than in recently laid, remnant or leggy hedgerows (0.18). Long-term reductions in the management of British hedgerows may therefore be exposing nesting songbirds to increased predation risk. We recommend regular rotational cutting of hedgerows to maintain a dense woody structure and thereby reduce songbird nest predation.

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1. Introduction

Nest predation is the main cause of nestling mortality in birds (Ricklefs, 1969), with losses to predators approaching 69% in some altricial species (Remes and Martin, 2002), sometimes leading to population sinks (Rogers et al., 1997). Species suffering high levels of nest predation have evolved behavioural and life-history strategies to minimise predation risk (Dunn et al., 2010; Eggers et al., 2005a; Martin, 1995) such as shorter nestling periods and multiple broods each year (Martin, 1995). Parents tend to reduce investment in a nest when predation risk is high, through reduced egg size (Fontaine and Martin, 2006), clutch size (Julliard et al., 1997) and clutch mass (Fontaine and Martin, 2006). High levels of activity around the nest may attract predators and parents often

reduce activity when the risk of nest predation is high (Conway and Martin, 2000; Dunn et al., 2010; Eggers et al., 2005b).

Behavioural adjustment by adult birds to reduce nest predation risk (Dunn et al., 2010; Eggers et al., 2005b) is dependent not only on predator activity, but also on the cover around the nest and the availability of food for chicks (Eggers et al., 2008). In areas where food abundance is low, high corvid abundance is associated with reduced nestling growth in a farmland songbird (Dunn et al., 2010). Ecological factors affecting the likelihood of nest predation include nest density (Cresswell, 1997; Schmidt and Whelan, 1998), predator abundance and nest type (i.e. cavity vs. open-cup, Fontaine et al., 2007). Nests that are more visible are more likely to be depredated at the egg stage (Martin et al., 2000; Matessi and Bogliani, 1999). Predation rates tend to increase with reduced vegetation cover, vegetation height, and nest height (e.g. Cresswell, 1997), all features that are likely to interact to influence nest detectability and accessibility (Cresswell, 1997), although there is no evidence for nest size affecting predation risk (Weidinger, 2004). Factors affecting nest predation risk may differ between predators: corvids

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are more likely to depredate poorly concealed nests, whereas well concealed nests are more likely to suffer depredation by rodents (Weidinger, 2002). There may be a trade-off for nest survival between nest concealment and the ability of parent birds to detect an approaching predator (Cresswell, 1997; Gotmark and Post, 1996; Weidinger, 2002).

Corvids are important nest predators, especially in farmland environments (Andren, 1992; Luginbuhl et al., 2001), and their populations in the UK have increased steadily since the 1960s, coincidental with the declines in many farmland songbirds (Gregory and Marchant, 1995). Whilst no clear link has been found between declining abundance of farmland songbirds and increasing abundance of corvids (Gooch et al., 1991; Madden et al., 2015; Newson et al., 2010; Thomson et al., 1998), local examples have shown predation impacts through farming management. Organic farms harbour more corvids, but fewer songbirds (Gabriel et al., 2010) and gamebird management (corvid control and sympathetic habitat management) is associated with higher nest survival and higher breeding densities of songbirds (Stoate and Szczer, 2001; White et al., 2008, 2014). An extensive analysis of song thrush and blackbird nest record cards found fine-scale spatial associations between corvid densities and nest survival rates (Paradis et al., 2000). That corvids are responsible for high numbers of nest losses is indisputable (Andren, 1992; Bradbury et al., 2000; Luginbuhl et al., 2001), and the linear nature of hedgerows in farmland landscapes may increase the risk of nest depredation (Chamberlain et al., 1995). Legal control of corvids is advocated and practiced for game management, and specifically for songbird conservation, but the control of one native species to benefit another is expensive and not universally accepted as a management practice. Thus, reducing corvid nest predation through habitat management would be desirable if possible, and, alongside measures to increase food availability during summer and winter, providing productive nesting habitat might help reverse population declines amongst some farmland bird species (Fuller et al., 1995). To our knowledge, no previous study has investigated impacts of hedgerow structure or management on nest predation risk in songbirds. The aims of the current study were (1) to identify the structural features of farmland hedgerows that influence nest site selection by songbirds, (2) to assess the relative importance of hedgerow structure and corvid abundance/proximity in determining nest predation risk, and (3) to identify aspects of hedgerow management that reduce nest predation risk.

2. Methods

2.1. Study sites

The fates of 399 songbird nests were monitored during April–July 2003 and 2004 across 11 farmland sites in total across two regions in eastern England (five in Cambridgeshire, Bedfordshire and Hertfordshire, and six in Leicestershire and Rutland). Not all sites were monitored in both years: 10 sites (5 in each region) were monitored in 2003 and seven sites (3 and 4 respectively) in 2004. The main species monitored were Blackbird *Turdus merula* ($n = 140$), Chaffinch *Fringilla coelebs* (83), Dunnock *Prunella modularis* (17), Linnet *Carduelis cannabina* (103), Yellowhammer *Emberiza citrinella* (28) and Song Thrush *Turdus philomelos* (8).

2.2. Nest finding and monitoring

Hedgerows were selected to cover the full range of hedgerow characteristics and management types present across study sites. Studied hedgerows ranged from intensively managed (usually less than 1 m high, with thin woody vegetation with gaps), through

managed (usually greater than 1 m high and cut or trimmed within the last 3–4 years) to unmanaged (usually >3 m high, not regularly cut or trimmed, often with trees and tall shrubs). Hedgerows next to busy roads, gardens, woods or woodland strips, or those planted within the last 5 years, were not selected for study.

Each hedgerow was cold-searched for nests at approximately weekly intervals between early April and late July. For each nest, the species was noted and the nest was inspected every 5–7 days until either the young fledged or the nest failed. Nest contents and adult activity were recorded during each visit. Nest success was inferred by an empty undamaged nest where the young were old enough to have fledged since the previous visit. Nest failure was either known (nest contained cold eggs, egg fragments or dead chicks) or was inferred from empty (often damaged) nests on a date prior to a plausible fledging date. For analytical purposes the date of failure was assumed to be the mid point between the last two visits. If there was evidence a nest had been pulled down from below, we assumed predation by a mammal, although we acknowledge that predator identification based on field signs is not always reliable (Pietz and Granfors, 2000). As we were specifically interested in corvid predation, nests for which mammalian predation was presumed were excluded from analyses ($n = 11$, 2.8%), as were any nests for which the outcome was uncertain ($n = 18$, 4.5%). A small number of failures caused by starvation, abandonment, human interference, or egg infertility (eggs not hatched or chicks found dead in the nest) were also excluded ($n = 24$, 6.0%). Analyses were restricted to nests located within the woody vegetation of the hedge; nests located on the ground or within field boundary vegetation were excluded. First egg date (FED; a day-specific integer where 1st January = 1) was deduced from incomplete clutches, hatch dates and estimated chick ages (e.g. Green, 2004). If FED could not be determined to within 3 days then the nest was excluded from analyses.

2.3. Nest site characteristics

Data describing nest site characteristics were collected for 338 nests within ten days of the nesting attempt ending and are defined in Table 1a (brief descriptions only are given here). We recorded nest height above the ground, along with the shortest horizontal depth and vertical depth between the nest and the hedgerow edge. We measured nest dimensions to allow the calculation of nest volume, and identified primary and surrounding plant species supporting the nest. Hedgerow height and width at the nest were measured to calculate cross-sectional area at the nest site.

Nest concealment was assessed in three different ways: light penetration at the nest (measured with a light meter), horizontal visibility (counts of white circles on a black card positioned next to the nest) and vertical vegetation cover (assessed from a digital image; see Table 1a for details). Nest accessibility (a binary variable) was assessed by attempting to manoeuvre two different sized balls from the hedgerow edge to the nest without breaking any woody vegetation (Table 1a). The smaller ball had a circumference (30.5 cm) that was similar to the maximum body girth of a magpie *Pica pica* (measured as 28 cm), and was intended to highlight potential accessibility to a corvid. Accessibility with the larger ball (69 cm) was intended to indicate easy access to a foraging corvid.

Locations of carrion crow *Corvus corone* and magpie nests were recorded, and the distance to the nearest corvid nest (corvid distance) subsequently calculated for each songbird nest. We also recorded distance to the nearest wood or woodland strip (wood distance), and distance to the nearest tree, pylon, telegraph pole or other vantage point at least 5 m in height (vantage distance) as corvids are visually-oriented predators known to utilise vantage points when searching for prey (Macdonald and Bolton, 2008).

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