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A new role for pond management in farmland bird conservation

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ABSTRACT

Biodiversity declines in agricultural landscapes represent a major conservation challenge. In the UK, some agricultural landscapes contain high pond densities, but many farmland ponds have become terrestrialised since the 1960s, with input of organic material resulting in a decrease in the size and depth of ponds that eventually transform into wet woodland habitats. Pond management, including removal of overhanging scrub and sediment, has proven highly effective in enhancing freshwater biodiversity. However, the implications of this management for farmland bird assemblages are unknown.

Bird surveys were undertaken at recently managed, open, macrophyte-dominated and at highly terrestrialised, macrophyte-free ponds in the intensively cultivated farmland of North Norfolk, UK. The diversity, abundance and composition of bird assemblages visiting these ponds were compared to determine responses to pond management by tree and mud removal.

Avian species richness, abundance and bird-visit frequencies were all higher at open farmland ponds. The observed patterns of bird occurrence were best explained by management-induced reductions in tree shading that resulted in aquatic macrophyte-dominance likely associated with high emergent invertebrate prey abundance. Moreover, we predict that open-canopy ponds offer greater habitat heterogeneity than overgrown ponds, allowing diversified bird use. Overgrown, terrestrialised ponds were preferred by some woodland bird species. Gamma diversity across the entire pondscape exceeded all individual pond alpha diversity measures by an order of magnitude, suggesting distinct variation in the bird assemblages visiting farmland ponds during different successional stages.

Pond management that generates a mosaic of pond successional stages, including open-canopy, macrophyte-dominated ponds, could help to address the long-term decline of farmland birds. We strongly advocate increased agro-ecological research in this field, combined with greater emphasis on ponds and pond management options in agri-environment schemes.

1. Introduction

Landscapes in many parts of the world are dominated by farmland (Foley et al., 2005; Scherr and McNeely, 2008). Accordingly, agricultural landscapes have attracted substantial attention from the conservation research community. Historically, agricultural landscapes represented a highly dynamic habitat mosaic characterized by substantial spatio-temporal variations in environmental conditions (Chamberlain et al., 2000; Bennett et al., 2006). The resulting heterogeneity, at both local and regional scales, has been recognised as a primary factor underpinning historical agricultural landscape biodiversity (Benton et al., 2003; Tscharntke et al., 2005; Fahrig et al., 2011). Accordingly, increases in agricultural intensification and associated agricultural habitat homogenization from the 1940s onwards, in combination with encroachments on remaining non-agricultural habitats, have resulted in a marked biodiversity reduction across the European countryside (Fuller, 2000; Ford et al., 2001; Robinson and Sutherland, 2002; Burel et al., 2004; Stoate et al., 2009; van Zanten et al., 2014).

Nearly 120 European bird species of conservation concern use lowland farmland habitats as either breeding or wintering habitat. A number of conservation priority species like the song thrush *Turdus merula*, yellowhammer *Emberiza citrinella* and reed bunting *Emberiza schoeniclus*, additionally rely on non-crop structures such as meadows, scrubland, woodlands, hedgerows and individual trees in agricultural landscapes as foraging, breeding and nesting sites (Whittingham et al., 2009; Marja and Herzon, 2012). Other birds such as skylark *Alauda arvensis* and grey partridge *Perdix perdix* are strongly affected by the quality of cropped habitats and marginal

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habitats such as fallows and rough ground. Some 83% of European farmland bird species have undergone declines in abundance between 1970 and 1990 as a result of agricultural intensification. For 86% of these species, reductions were significant, and these trends have continued into the 21st century (Fuller et al., 1995; Donald et al., 2001; Barker, 2004; Holland, 2004; Butler et al., 2007; Baillie et al., 2014). Threats identified as affecting conservation priority bird species include the loss of old hedgerows, permanent pasture and scrub on farmland, changing sowing regimes, loss of variation in grassland swards, declines in abundance and diversity of insect prey, and reductions in seed resources linked to land-use changes and pesticide use (Chamberlain et al., 2000; Hinsley and Bellamy, 2000; Perkins et al., 2000; Donald et al., 2001; Benton et al., 2002; Barker, 2004; Holland, 2004).

While a range of approaches to enhance the farmed environment for wildlife have been taken in the UK and across Western Europe, many bird species populations have failed to recover (Donald and Evans, 2006). Declining UK Biodiversity Action Plan (BAP) species (JNCC, 2007) include skylark, starling *Sturnus vulgaris*, grey partridge and yellow wagtail *Motacilla flava* (Eaton et al., 2013). Aerial insectivorous birds associated with agricultural environments, such as swift *Apus apus* and house martin *Delichon urbicum*, have also shown steep population declines across industrialised European countries (Benton et al., 2002; Rioux Paquette et al., 2014). With farmland bird declines surpassing those in all other environments, serious concerns amongst both the scientific community and the general public have been raised. Currently, the main approach for counteracting farmland bird declines in Europe is the widespread adoption of agri-environment schemes (AES), such as the English Countryside Stewardship Schemes, but these have afforded limited success thus far for agricultural biodiversity (Kleijn et al., 2006, 2011; Baker et al., 2012).

A number of studies have concluded that agricultural management approaches that increase the heterogeneity of the agricultural mosaic will enhance overall species richness across many taxonomic groups at the landscape scale, while simultaneously improving ecosystem services and minimising agricultural yield losses (Pino et al., 2000; Atauri and de Lucio, 2001; Weibull et al., 2003; Doxa et al., 2010; Sabatier et al., 2014). Soininen et al. (2015) stressed the importance of aquatic habitats for conservation, not only for aquatic organisms, but also for terrestrial species due to the contribution of potential cross-system subsidies from freshwater ecosystems which enhance terrestrial ecosystem functioning. Small wetlands, and especially ponds, may therefore play a crucial role in improving both aquatic and terrestrial biodiversity at the landscape scale, while also serving to increase habitat heterogeneity (Williams et al., 2004; Davies et al., 2008; Céréghino et al., 2008; Lemmens et al., 2013).

Ponds are of particular significance to biodiversity conservation in agricultural landscapes, forming habitat islands for a wide range of aquatic and semi-aquatic organisms in an otherwise species-poor environment (Declerck et al., 2006; Davies et al., 2008; Ruggiero et al., 2008). Unfortunately, many farmland ponds are threatened by in-filling (via land reclamation) and pollution due to agricultural intensification (Wood et al., 2003; Biggs et al., 2005; Céréghino et al., 2014). In addition, as a consequence of the general cessation of traditional pond management practices over the last 30–40 years (Sayer et al., 2013), a high proportion of UK farmland ponds have undergone terrestrialization, with the accumulation of litter and other organic material over time resulting in a decrease in pond size and depth. Many ponds also become increasingly encroached by woody vegetation and eventually transform into wet woodland, while in the absence of shrub and tree encroachment, pond succession can lead towards fen-swamp habitats. Indeed, in many areas, overgrown, tree-shaded ponds are overwhelmingly dominant, resulting in sharp declines in landscape-scale aquatic diversity (Sayer et al., 2011, 2012). Approaches to combat widespread terrestrialisation include the creation of new ponds through initiatives such as the UK Million Ponds Project (Williams et al., 2010). As an alternative, existing, overgrown farmland ponds can be managed and restored via the removal of encroaching trees, scrub and accumulated pond sediment. The latter process effectively 'resets' succession thereby increasing the quality and quantity of open water habitats. Sayer et al. (2012) determined that macrophyte and invertebrate diversity was greatly enhanced in a managed pondscape comprising a mosaic of ponds at different successional stages set in an intensively managed agricultural landscape. Diversity patterns were strongly driven by degree of shading, with agricultural ponds previously deficient in macrophytes becoming macrophyte–dominated after management, providing habitat for a diverse array of species. Currently, both the UK Countryside Stewardship Scheme (CS) and Glastir Land Management Scheme for Wales offer options for maintaining and buffering ponds on farmland (Welsh Government, 2015; Natural England, 2015). Nonetheless, pond management itself is only included as a higher tier option within CS, and overall pond management remains relatively poorly promoted within UK AES.

While the influence of pond management on aquatic species assemblages is now established (Gee et al., 1997; Sayer et al., 2012), the links between pond management and the terrestrial environment have been comparatively neglected. Farmland ponds generally harbour substantial numbers of aquatic macroinvertebrates whose adult aerial stages are known to constitute an important food resource for nesting and fledging birds (Newton 1998; Baxter et al., 2005; Richardson et al., 2010; Schummer et al., 2012; Stenroth et al., 2015), and wintering waterbirds (Matuszak et al., 2014). In addition, mixed grassland margins around open ponds may increase the availability and diversity of broad-leaved plants and seeds utilised as a food resource by granivores (McCracken and Tallowin, 2004); we believe that these open pond margins are of high importance to birds.

We examine the value of a set of open, managed ponds and overgrown, non-managed ponds for bird communities in the intensively farmed agricultural landscape of North Norfolk, Eastern England. We predict that the benefits of pond management will strongly affect terrestrial organisms, as exemplified by the farmland bird community. The term 'farmland bird' in this context is used to encompass any species encountered within the agricultural landscape. This includes waterfowl, reed-nesting species, ground-nesting species and birds of prey, as well as open-country, woodland, scrubland and grassland bird species. We hypothesize that managed, macrophyte-dominated ponds attract a greater diversity of bird species than unmanaged, overgrown ponds, since they not only provide a higher diversity and abundance of emerging invertebrates and greater seed provision subsidy, but also increase habitat heterogeneity in the farmland landscape through provision of vegetated water and wet reed/sedge-dominated margins. We furthermore hypothesize that overgrown ponds primarily act as woodland habitat islands, occupied predominantly by woodland bird species. We finally hypothesize that bird assemblages use open and overgrown ponds for different activities in accordance with variations in habitat preference and food availability.

2. Methods

2.1. Study site

This study was conducted at four adjacent, intensive, mixed arable and cattle farms located between the villages of Melton