Biological Conservation 220 (2018) 122–131

Contents lists available at ScienceDirect

Biological Conservation

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

The influence of hedgerow structural condition on wildlife habitat provision in farmed landscapes

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ARTICLE INFO

Keywords:
Hedgerow
Habitat structure
Management
Conservation
Agri-environment

ABSTRACT

In this review, we discuss the role of hedgerow structure and condition in determining the value of hedgerow habitat for biodiversity conservation within an agricultural context, to inform and evaluate hedgerow management decisions and policy. Through a systematic literature review, narrative synthesis and vote counting, key structural condition indicators were identified for a range of conservation priority taxa. Abundance, survival or fecundity of ground vegetation, birds, mammals and invertebrates were affected by height, width, woody biomass, foliar quality and quantity, and gappiness of hedgerows. Although general patterns may not occur, a response to a particular structural feature can vary both within and between taxonomic groups, many responses are synergistic and interdependent. In conclusion, the definition of a "good quality" hedgerow for biodiversity conservation should be expanded to include all those key structural features which are important across taxa. Furthermore, the importance of heterogeneity in hedgerow structural condition is highlighted, where no fixed set of hedgerow characteristics were found to benefit all taxa. If uniform hedgerow management is overprescribed, as has been the tendency with some agri-environment schemes, some species (including those of conservation concern) are likely to be adversely affected by a loss of suitable habitat or resource decline.

1. Introduction

Hedgerows consist of lines of trees, shrubs, and associated herbaceous understory vegetation, forming a contiguous network across the farmed landscapes of temperate Western Europe (Hannon and Sisk, 2009), with similar features found elsewhere (e.g. in Canada, Australia and Scandinavia (Boutin et al., 2001); the mediterranean (Connor et al., 2014); and North America (Morandin et al., 2016)). Their species composition is floristically native (French and Cummins, 2001). In Europe, woody species typically include *Prunus spinosa* (blackthorn), *Crataegus* spp. (hawthorn), *Corylus avellana* (hazel), *Rosa canina* (dog rose) and *Sambucus nigra* (elder) (French and Cummins, 2001; Gosling et al., 2016). In the Republic of Ireland, hedgerows cover 1.5% of land surface area (Smal, 1995), equating to 11% of farm area (Sheridan et al., 2017). In Great Britain, the extent of hedgerows (477,000 km as of the 2007 Countryside Survey) make them one of the largest (Carey et al., 2008) and most widely distributed (Baudry et al., 2000) semi-natural habitats within farmed landscapes.

Traditionally built for stock proofing and provision of shelter (Baudry et al., 2000), hedgerows play a wider role in biodiversity conservation; providing food, shelter and breeding sites for a range of species typically dependent on woodland edge, scrub or grassland habitats (Hinsley and Bellamy, 2000; Merckx et al., 2012; Staley et al., 2016; Lecq et al., 2017), and may also facilitate movement of organisms through the landscape (Cranmer et al., 2012; Slade et al., 2013). Hedgerow structure and landscape context can also influence microclimate (Walker et al., 2006). Hedgerows thus contribute to the conservation of biodiversity locally, regionally and internationally by providing refugia in landscapes that otherwise lack in suitable habitat, food and shelter (Weibull and Ostman, 2003). Hedgerows across Europe are considered a priority habitat for conservation efforts (JNCC and Defra, 2012). UK hedgerows for instance have been associated with > 600 plant species, 1500 insects, 65 birds and 20 mammals (UK Biodiversity Steering Group, 1995). Hedgerow habitat is also noted as important for species of conservation concern, which face multiple pressures within the agricultural landscapes of Europe (Webb et al., 2010). Conservation actions involving hedgerow management were specifically recommended for 45 of the priority species afforded legislative status under section 41 of the Natural Environment and Rural Communities (NERC) act in the UK (Natural England, 2013). The presence of hedgerows is a consistent predictor of abundance for conservation concern bird species and farmland specialist bird species in

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https://doi.org/10.1016/j.biocon.2018.02.017
Received 14 July 2017; Received in revised form 31 January 2018; Accepted 9 February 2018

Poland (Sanderson et al., 2009; Wuczyński, 2016), and the UK (Hinsley and Bellamy, 2000). In an Italian study the abundance of five common spring and four common winter birds are associated with the % cover of hedgerows in the landscape (Assandri et al., 2017). The biodiversity supported by hedgerows influences the provision of pest regulation (Morandin et al., 2014) and pollination services (Morandin and Kremen, 2013b; Morandin et al., 2016), essential for agricultural productivity (Natural England, 2012).

Although once widespread, hedgerow removal is becoming less common across Europe (Baudry et al., 2000) and is now restricted by law in the UK (Oreszczyn and Lane, 2000). However, the value and importance of a hedgerow is not necessarily ensured simply by its presence or that of a hedgerow network, on a farm or in the wider landscape, but is shaped by hedgerow management and resulting habitat quality (Homberger et al., 2017). Management has a strong effect on hedgerow structural condition (Hinsley and Bellamy, 2000; Maudsley, 2000; Staley et al., 2015). Hedgerow structure is complex, providing a range of niche habitats and food provisions throughout the year (Weibull and Ostman, 2003), not found elsewhere within the surrounding agricultural matrix. Management is therefore essential throughout the lifecycle of a hedgerow, having the potential for positive influence on the biodiversity of agri-ecosystems (La Coeur et al., 2002). Both the timing and techniques of hedgerow management play a role in determining the structural condition and value of hedgerows as a wildlife habitat (Croxton et al., 2002). An absence of management can be as detrimental to hedgerow structural condition as over-frequent management (Garbutt and Sparks, 2002). For example, absence of hedgerow management led to a 23% decrease in managed hedgerow length between 1984 and 2007 in Britain, contributing to a 49% increase in the length of lines of trees and relict hedgerows over the same period (Carey et al., 2008). There is also a trend to value and maintain "neat" or "tidy" farm landscapes and hedgerows in the UK, Ireland and France (Oreszczyn and Lane, 2000; Britt et al., 2011; Power et al., 2013; Kohler et al., 2014). Such changing attitudes and management practices over time have meant changes to the structural condition and value for wildlife of not only individual hedgerows but the whole agricultural landscape.

Hedgerows are recognised both as a priority wildlife habitat and as an important part of ecological networks in the UK (Wolton, 2009b; Lawton, 2010), Belgium (Deckers et al., 2005), France, Germany and Ireland (Baudry et al., 2000). Within agri-environment policy, that of the EU is considered to have the most thorough scientific assessment and widest scope (Heath et al., 2017). Hedgerow planting, management and maintenance play a significant role within agri-environment schemes across Europe (Alignier and Baudry, 2015). In the United States, farmers are encouraged through voluntary on-farm conservation projects to offset the impacts of agricultural intensification, yet little hedgerow management advice is provided (Heath et al., 2017).

The recently implemented Countryside Stewardship scheme in England provides payments for traditional hedgerow laying, coppicing and management of the cutting regime (cutting on a 2–3 year rotation ideally in late winter), with the aim of encouraging taller and wider hedgerows, with increased berry and blossom provisions (Natural England, 2016). Similar schemes operate elsewhere in Europe (Fuentes-Montemayor et al., 2011). Currently only 48% of UK hedgerows are considered to be in "good condition" (Norton et al., 2012). This assessment is based on meeting numerous thresholds, including criteria centred on structural condition: hedgerow height should be a minimum of 1 m, width a minimum of 1.5 m and cross-sectional area a minimum of 3 m^2. Structural integrity and connectivity are also increasingly important in the assessment of 'good condition' hedgerows (Defra, 2007).

Habitat structural condition refers to the composition, spatial distribution and characteristics of a habitat's features, which contribute to habitat suitability and provide a sufficient quantity and quality of resources for a range of taxa. In this review, we summarise the effect of hedgerow management techniques on a range of individual structural features, using this information to explore synergies and conflicts in the management of hedgerows for biodiversity and for individual taxa. Few previous attempts to collate the findings of studies on different taxa exist in this context, none of which are recent (Barr et al., 2005). This is despite the gap in our understanding of potential complementarity, and conflicts in hedgerow structural requirements between taxa being highlighted over a decade ago within an international review of hedgerow management (Baudry et al., 2000). Furthermore, previous studies assessing the effects of hedgerow structure on wildlife conservation have not considered the cyclic management of hedgerows (Baudry et al., 2000) or the seasonality of the presence and use of individual structural components.

2. Review methodology

2.1. Review structure and approach

We begin by considering the impacts of cutting and rejuvenation techniques on woody hedgerow structure and habitat quality. Secondly, we review the association of a wide range of taxa with individual component features and characteristics of the hedgerow. Attention is given to two case studies: *Erinaceus europaeus* (European hedgehog), once widespread but now of conservation concern (listed 'of principal concern' in Section 41 of the Natural Environment and Rural Communities Act, 2006); and Lepidoptera, the most studied invertebrate taxa, with a range of responses to hedgerow management and structural condition.

Although this review is relevant to the management of a habitat type acknowledged in the literature as ecologically important across geographically diverse agri-ecosystems, most of the evidence collated in this review comes from the UK and Western France from where the bulk of the most recently published research originates (Baudry et al., 2000) (Table 1a). Despite this, exploring the synergies and conflicts in the management of hedgerows for the conservation of a wide range of species with differing habitat requirements has international relevance for agri-environment policy and hedgerow management.

2.2. Systematic literature review

Using the Science Direct, CAB abstracts, and IHS Environmental Management databases, the search terms 'hedge', 'hedgerow', 'fencerow', 'green lane' and 'greenway' returned 9827 unique articles published between 1990 and 2017. This initial search was narrowed to obtain information regarding specific taxa, habitat structural components and management techniques as necessary (Table 1), selecting the included literature based on reading of titles and abstracts in the English language.

It is worth acknowledging that defining a hedgerow is, as discussed in Wright (2016), challenging, as hedgerows are subject to regional variation in form and function. Throughout this review we consider hedgerows to be distinctive, and dynamic woody landscape features, actively managed for their function, thereby excluding other similar linear vegetation (51 studies). The exclusions included relict and defunct hedgerows, lines of trees, and fencerows (a term which dominantly refers to unmanaged, relict and uncultivated herbaceous vegetation) in the Americas that do not meet this definition, having had a different natural or management history to hedgerows (Sutton, 1992). We excluded studies which only considered the presence or abundance of hedgerows in the landscape (76 studies) rather than their structural condition and management. Urban hedgerows (4 studies) are also excluded from this review, although also important habitats for wildlife (Gosling et al., 2016), they are less studied than their rural counterparts. Discussion of hedgerow banks, ditches, and debris (Lecq et al., 2017), also fall beyond the scope of this review (2 studies).

Precedence was given to studies published since the 2005 review of a similar nature (Barr et al., 2005). Primary research was prioritised