Agriculture, Ecosystems and Environment 211 (2015) 207–220

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Riparian buffer strips: Their role in the conservation of insect pollinators in intensive grassland systems

Lorna J. Cole[a,*], Sarah Brocklehurst[b], Duncan Robertson[a], William Harrison[a], David I. McCracken[a]

[a] Future Farming Systems, Scotland's Rural College, Auchincruive, Ayr, KA6 5HW, UK
[b] Biomathematics & Statistics Scotland, James Clerk Maxwell Building, The King's Buildings, Peter Guthrie Tait Road, Edinburgh EH9 3FD, UK

ARTICLE INFO

Article history:
Received 26 March 2015
Received in revised form 12 June 2015
Accepted 16 June 2015
Available online 13 July 2015

Keywords:
Pollination
Plant-pollinator interactions
Bees and butterflies
Vegetated buffer strips
Agri-environment schemes
Biodiversity

ABSTRACT

There is growing concern that the global decline of insect pollinators will adversely influence the stability of pollination in agricultural and terrestrial ecosystems. By enhancing habitat heterogeneity and ecological connectivity, riparian buffer strips have the potential to promote insect pollinators in intensively managed landscapes. Insect pollinators and flowering plants were investigated on a range of riparian margins, and their adjacent grassland fields, to determine the main physical and botanical attributes driving pollinator diversity.

Irrespective of whether they were fenced or not, riparian margins had richer plant assemblages and supported more pollinators than grassland fields. While the erection of fences did not enhance the richness or diversity of flowers, fenced riparian buffer strips supported more even and diverse assemblages of bumblebees and a greater number of butterflies than unfenced riparian margins. More bumblebees and butterflies were recorded in wide buffer strips (i.e. over 5 m wide) than in unfenced margins or narrow buffer strips (i.e. ≤3.5 m wide) and butterfly assemblages in wide buffer strips were richer and more diverse. There was a strong positive relationship between floral resources and the abundance, richness and diversity of bumblebee and butterfly assemblages. Pollinators only foraged on a small number of the flower species present and impacts of fencing and buffer strip width could not solely be attributed to the area and/or species richness of flowers.

Fenced riparian buffer strips, particularly when over 5 m wide, have the potential to provide resources for insect pollinators in intensively grazed systems. Management to enhance floristic diversity (to provide a more continuous supply of pollen and nectar) and tussock forming grasses (to provide shelter for pollinators and nesting locations for bumblebees) could further increase their value to insect pollinators. In grassland systems, restricted grazing is easier to implement than mowing. It is, however, important that grazing management does not unduly interfere with other ecosystem services derived from riparian buffer strips (e.g. diffuse pollution mitigation). Widespread fencing of watercourses at the catchment level could result in the simplification of these inherently dynamic and complex habitats. Buffer strips should therefore be strategically placed to optimise benefits such as ecological connectivity and diffuse pollution mitigation.

1. Introduction

The post war intensification of agricultural practices and the associated loss of landscape heterogeneity have adversely affected biodiversity across a range of taxa (Benton et al., 2003; Tscharntke et al., 2005). There is growing concern that this loss of biodiversity will have an adverse impact on ecosystem functioning, resulting in a degradation of ecosystem services (Albrecht et al., 2012; Flynn et al., 2009). Evidence is mounting that insect pollinators (including honeybees, wild bees, butterflies and hoverflies) are declining globally and with losses being biased towards species with specific habitats, diets and functional traits, the stability of the pollination services they deliver is under threat (Potts et al., 2010; Vanbergen and Insect Pollinator Initiative, 2013). With insect pollinators enhancing yields in almost 70% of crops, accounting for approximately 35% of agricultural production, declines pose a genuine threat to global food security (Klein et al., 2007). Furthermore, insect pollinators are responsible for the pollination

* Corresponding author.
E-mail address: Lorna.Cole@sruc.ac.uk (L.J. Cole).

http://dx.doi.org/10.1016/j.agee.2015.06.012
0167-8809/

of the many wild plants and thus play a vital role in the maintenance of terrestrial ecosystems (Biesmeijer et al., 2006; Ollerton et al., 2011).

Within intensively managed agricultural landscapes, natural or semi-natural components provide important nesting and foraging sites for insect pollinators and proximity to such habitats has been found to increase pollinator species richness, crop visitation rates and pollination success (Blaauw and Isaacs, 2014; Garibaldi et al., 2011, 2014; Petersen and Nault, 2014; Ricketts et al., 2008). There has been considerable research on the role that field margins play, especially when managed for conservation, in providing foraging and nesting sites for insect pollinators within intensively managed agricultural landscapes (Carvell et al., 2007; Kells and Goulson, 2003; Feber et al., 1996; Potts et al., 2009; Pywell et al., 2011; Scheper et al., 2013). This research has, however, focussed primarily on field margins that are not exclusively riparian (e.g. arable buffer strips, wildflower strips and grassland field margins) and comparable research looking specifically at riparian field margins is lacking. Riparian margins occur in the transitional zone (i.e. ecotone) between aquatic and terrestrial habitats and are typically subjected to disturbance by watercourses which results in the formation of functionally distinctive and dynamic ecosystems that support many specialist species. The properties of riparian margins are thus unique and consequently research findings from non-riparian field margins are unlikely to be directly transferable to riparian field margins. Furthermore, in grassland situations, buffer strips are generally established by erecting fences adjacent to watercourses to exclude livestock with the resultant vegetation being typically left unmanaged. The resultant vegetation is tall and dense and while having a tendency to be species poor; it can be structurally diverse encompassing flower heads, seed heads and grassy tussocks (Cole et al., 2012a; Stockan et al., 2012; Woodcock et al., 2009). Arable riparian buffer strips, in contrast, are frequently established without the use of fences and disturbance (e.g. annual cutting) is relatively common. As a result of differences in establishment and management, findings from arable buffer strips are not directly transferable to grassland buffer strips.

Previous pollinator research on field margins has concentrated on how the presence of margin establishment (e.g. natural regeneration verses different seed mixtures) and management (e.g. cutting verses no cutting) influences insect pollinators (Carvell et al., 2007; Feber et al., 1996; Holland et al., 2015; Potts et al., 2009; Pywell et al., 2004, 2005, 2011) with few studies focussing specifically on the impact of margin width (Bäckman and Tiainen, 2002; Field et al., 2005). With increasing pressure on agricultural land to meet growing demands for food (Garnett et al., 2013), there is a need to ensure that the area of land taken out of production is kept to a minimum and the resultant loss of yield is balanced with the benefits gained. Furthermore, landscape context can significantly influence the benefits derived from agri-environment measures with greater benefits to insect pollinators occurring in landscapes with intermediate levels of heterogeneity (Scheper et al., 2013). It is therefore important to increase our understanding of how field margin width influences biodiversity and also to consider the spatial location and landscape context of margins to ensure that the ecosystem services derived are optimised.

Fenced riparian buffer strips are a key agri-environment measure primarily aimed at protecting watercourses from diffuse pollution and their prevalence in intensively managed agricultural catchments is likely to become more widespread (McCracken et al., 2012). There is therefore a need to formulate management prescriptions that capitalise on the range of potential benefits that riparian buffer strips can deliver (e.g. biodiversity, pollination, protection of watercourses and ecological connectivity). The impact of fencing riparian field margins is taxa specific and while some groups including phytophagous invertebrates (Cole et al., 2012a), woodland carabids (Stockan et al., 2014) and flightless carabids (Cole et al., 2012b), are favoured by fencing, other groups including Linyphiidae spiders (Cole et al., 2012a) and vascular plants (Feehan et al., 2005; Stockan et al., 2012), are adversely affected. As insect pollinators are strongly driven by floral resources (Potts et al., 2009; Scheper et al., 2013), adverse effects of fencing on flowering plants is likely to have knock-on effects on pollinators. Management prescriptions for riparian buffer strips aimed at enhancing floristic diversity must be tailored to meet regulations that restrict certain agricultural practices adjacent to watercourses (e.g. cultivation and the application of agro-chemicals) and to ensure that they do not conflict with other functions that riparian buffer strips deliver (e.g. mitigating diffuse pollution). Advancing understanding of pollinator ecology within intensive grassland systems will assist in the formulation of agri-environment prescriptions for riparian field margins that promote insect pollinators and enable landowners to capitalise on the benefits derived from land taken out of production.

This research aimed to determine the main physical and botanical attributes of riparian field margins, and their adjacent grassland fields, that influence the taxonomic structure and diversity of butterfly and social bumblebee (i.e. excluding subgenus *Psithyrus*) assemblages in intensive grassland systems. Butterflies and social bumblebees were selected as they are easily identified in the field and while they both rely strongly on nectar, they have very different lifecycles and habitat requirements and are thus sensitive to different factors (Potts et al., 2009; Holland et al., 2015). The main factors driving diversity in these two key groups of pollinators were assessed to determine if fenced riparian buffer strips supported more foraging pollinators than unfenced riparian margins, and, if so, to determine if wider riparian buffer strips were superior to narrow buffer strips.

2. Methods

2.1. Study sites

Two lowland regions of Scotland dominated by productive *Ryegrass*,*Lolium perenne* L., swards were selected for study over a two year period (2010 and 2011); Ayrshire (N55°32′50″, W4°22′00″) and Kirkcudbrightshire (N54°51′35″, W4°01′48″; Cole et al., 2012a). Agricultural management in both geographical locations is typically intensive livestock grazing and/or cutting for silage. A total of 26 sampling sites on 14 farms were surveyed over the two year period, 14 sites in Ayrshire and 12 in Kirkcudbrightshire. Sites were chosen to represent the range of riparian margins occurring within the two study areas. Sites were classified into one of three riparian management types: unfenced margin sites (i.e. no fences between fields and watercourses, $n = 9$), narrow fenced buffer strips sites (i.e. fences erected 1–3.5 m from the watercourse, $n = 9$) and wide fenced buffer strip sites (i.e. fences erected more than 5 m from watercourses, $n = 8$) (Table 1). At each site, paired transects were established, one adjacent to the watercourse (termed margin transects: unfenced margin, narrow buffer strip and wide buffer strip) and one approximately 20 m from the watercourse in unfenced sites, or from the fence in the case of buffer strip sites, into the adjacent grassland field (termed field transects: unfenced field, narrow field and wide field).

2.2. Insect pollinator and botanical sampling

Pollinators were monitored using standardised transect walks 100 m in length and 2 m on either side, and 2 m in front (i.e. transect area: 100 m by 4 m), of the observer (Pollard and Yates, 1993; Potts et al., 2009). Transect walks were conducted between