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Arthropod communities in warm and cool grass riparian buffers and their influence on natural enemies in adjacent crops

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ABSTRACT

Riparian buffers of native warm season (WSG) or non-native cool season (CSG) species are commonly planted along margins of crop fields as part of the USDA Conservation Reserve Program. The soil, water and wildlife enhancement values of these buffers are well researched and documented. However, their conservation value for biological control is largely unknown. In this study, we examined and compared arthropod communities in WSG and CSG buffers and focused specifically on their influence on natural enemy populations in adjacent crops. Plant diversity measurements and relative estimates of epigeal and canopy-dwelling arthropods using pitfall trapping and sticky cards were recorded in 29 buffers of each grass type and adjoining crop fields during two years in Maryland. We predicted that the structurally more diverse and less stressed WSG buffers are more suitable for enhancing arthropod biodiversity and provide greater conservation value for natural enemies. Results demonstrated that the composition and relative abundances of most epigeal and canopy-dwelling taxa in both grass buffers corresponded with the composition and relative abundances of those taxa in neighboring crops, suggesting population linkage and movement of taxa between buffer and crop habitats. However, warm and cool season grasses in riparian buffers were inhabited by dissimilar arthropod communities in terms of taxa richness, abundance and composition, which in turn influenced differently the beneficial arthropod communities in adjacent crops. Contrary to our hypothesis, cool season grasses supported greater abundances of most beneficial arthropods in buffers and also enhanced their populations in adjacent crop fields, especially early in the growing season. Beneficial taxa responses were likely linked to differences in the early season phenology of the grass types. Although WSG buffers are green and actively growing during the summer, CSG grasses break dormancy earlier in the spring and provide higher quality food for many arthropod taxa that serve as prey and hosts for predators and parasitoids. Given this early season advantage, the addition of perennial flowering forbs to the CSG mixes is suggested to enhance their conservation value by improving structural complexity and providing floral resources to support natural enemy populations.

1. Introduction

The Conservation Reserve Program (CRP), implemented by the United States Department of Agriculture (USDA) Farm Service Agency (FSA), re-establishes valuable grassland to improve water quality, prevent soil erosion, and replace lost wildlife habitat (USDA, 2012a, 2012b). The program offers incentive payments to encourage landowners to protect environmentally sensitive areas by converting highly erodible cropland to riparian habitats. Land enrolled in the program remains out of crop production usually 10–15 years. As of September 2016, 9.55 million ha were enrolled in CRP, and a recent initiative now provides cost-share to landowners to establish buffer habitats that are friendly to pollinator taxa (USDA, 2012a, 2012b). This is the first CRP practice that is specifically designed to benefit arthropods.

A riparian buffer bordering crop fields is one of several conservation practices available to landowners under the CRP. These buffers contain strips of permanent vegetation that are generally planted to protect environmentally sensitive areas from contiguous land management practices. Riparian buffers improve water quality by filtering nutrients and trapping sediment, provide refuge for the maintenance of biological diversity, and help preserve the natural hydrology of waterways (Naiman and Decamps, 1997; Lovell and Sullivan, 2006; Johnson et al., 2016).

In 2014, nearly 18,875 ha of land were enrolled in CRP as riparian

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buffers in Maryland (EWG, 2015). Seventy percent of riparian buffers are herbaceous filter strips planted along field edges of arable land and greater than 90% are located on the Eastern Shore of Maryland (USDA FSA, 2013). Riparian buffers (hereafter, referred to as grass buffers) are planted with warm season (WSG) or cool season (CSG) grass species, and often seeded with a mix of legumes and perennial flowering forbs. WSG buffers include one or more of the following native prairie species: switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizavhyrium scoparium*), and Indian grass (*Sorghastrum nutans*) (Tjaden and Weber, 1998). Warm season grasses break dormancy by late spring, grow during summer months, set seed in the fall, and go dormant during the fall after a freeze. Warm season grasses have deep root systems, are drought tolerant, and can remain green during high temperatures. Although WSG buffers are encouraged by the CRP to perpetuate native species, approximately two-thirds of grass buffers in Maryland are planted with non-native CSG species, primarily orchardgrass (*Dactylis glomerata*), red fescue (*Festuca rubra*), and sheep fescue (*Festuca ovina*) (Tjaden and Weber, 1998; Lynn, 2003). Cool season grasses break dormancy when soil temperatures are just above freezing and start growth earlier in the spring than WSGs. Cool season grasses set seed in early summer, thrive during cool temperatures and rainfall from early spring to summer, and then taper off or go completely dormant during hot, dry summer months. If moisture is adequate, they resume growth in the fall. Landowners prefer CSG over WSG buffers because they are less expensive, easier and quicker to establish, less laborious to maintain, and often create a more aesthetic habitat.

Research directed at demonstrating environmental benefits of CRP plantings has focused primarily on their potential to contribute to soil organic carbon and nitrogen pools (Munson et al., 2012; O'Connell et al., 2016; Whisler et al., 2016), as well as provide habitat for birds (McCoy et al., 2001; Coppedge et al., 2004; Blank, 2010) and mammals (Phillips et al., 2004; Kamler et al., 2007; Stanley, 2010). Consequently, few studies have quantified effects of different grasses in CRP lands on insects and other arthropods. Research conducted to evaluate impacts of CRP on arthropods have mainly focused on their potential to enhance communities of butterflies (Reeder et al., 2005; Davros et al., 2006; Dollar et al., 2013, 2014), crop pests (Phillips et al., 1991; Carroll et al., 1993; Mowry et al., 1995; Lefko et al., 1998), and to provide arthropod prey for grassland birds (McIntyre and Thompson, 2003; Benson et al., 2007). As such, there is a significant gap in our understanding of arthropod community responses to riparian grass buffers, especially with respect to their conservation value for arthropod natural enemies (French et al., 1998).

Several reviews have shown that uncultivated habitats neighboring crops can help sustain populations of natural enemies of agricultural pests by providing alternative food sources, floral resources, prey or hosts, overwintering sites and refuge (Landis et al., 2000; Maudsley, 2000; Sunderland and Samu, 2000; Marshall and Moonen, 2002). Most insect predators overwinter in these neighboring habitats because they provide a more favorable microclimate during winters than sparsely vegetated crop fields (Luff, 1966; Thomas et al., 1991; Landis et al., 2000). Structural parameters of the overwintering vegetation can influence natural enemy survival. For example, winter survival of carabid beetles, important predators in many cropping systems (Kromp, 1999; Melnychuk et al., 2003; Witmer et al., 2003), is positively correlated with vegetation height (Dennis et al., 1994), successional age (Frank and Reichhart, 2004), number of grass tussocks, and leaf litter depth (Thomas et al., 1992a) of non-crop habitats. Other predators and parasitoids are known to also overwinter in non-crop habitats (Landis and Haas, 1992; Bruck and Lewis, 1998; Tscharntke et al., 2002), including mymarid wasps (Corbett and Rosenheim, 1996), lady beetles (Bianchi and van der Werf, 2003), rove beetles (Frank and Reichhart, 2004), and spiders (Lemke and Poehling, 2002; Pywell et al., 2005). In general, overall arthropod diversity increases within crops when fields are bordering uncultivated habitats with favorable overwintering conditions (Dennis and Fry, 1992).

Tussock-forming grasses, such as switchgrass, are particularly favorable for overwintering arthropods because they are structurally diverse and provide microclimates that favor their survival (Luff, 1966; Dennis and Fry, 1992; Thomas et al., 1992b; Dennis et al., 1994). Grasses that grow in tussocks harbor greater abundance and species richness of arthropods than grasses that cover the habitat more uniformly (Dennis et al., 1998; Collins et al., 2003). Additionally, McIntyre and Thompson (2003) found greater densities of arachnids, coleopterans, orthopterans, and lepidopterans in native WSG prairie than in mixed and non-native grasses. In general, native grasses are expected to harbor co-evolved specialist and invasive generalist taxa, while generalist arthropods are predicted to more common in introduced plant species (Strong et al., 1984; Lankau et al., 2004). Additionally, WSG buffers are mixed more often with flowering forbs than CSG buffers, and mixed plantings are expected to provide more alternative food sources and have greater impact on reproductive rates of natural enemies (Baggen and Gurr, 1998).

Arthropod richness and abundance are also influenced by cultural practices used to manage landscape vegetation. For example, arthropod community diversity tends to be greater in moderately to frequently disturbed habitats (DiGiulio et al., 2001). This is relevant as WSG and CSG buffers are generally managed differently. Cool season grass buffers are mowed annually during the fall but the hay is not removed, whereas WSG buffers are subjected to fewer disturbances, usually a light tilling (with a tandem disk harrow) or controlled burning every 3–4 years. Benson et al. (2007) found that arthropod abundance and biomass were greater within disked compared to undisked portions of fields. The disking decreased the cover of grasses, litter and standing dead vegetation but resulted in greater plant species richness within the riparian grassland. However, cool season grasses may become less favorable for arthropod communities as the summer passes due to a decline in grass quality. These grasses become stressed during hot and dry conditions, whereas warm season grasses remain green and actively grow throughout summer months.

Riparian grass buffers have the potential to support diverse communities of natural enemies and serve as corridors for their movement into neighboring crops. However, the conservation biological control value of these non-crop habitats is largely unknown. In this study, we examined the arthropod communities in CRP grass buffers and focused specifically on their influence on arthropod natural enemies in adjacent crops. To test our hypothesis that WSGs are more suitable for enhancing arthropod biodiversity thereby providing greater conservation value for arthropod natural enemies, we addressed the following questions: (1) do WSG buffers harbor greater numbers and diversity of arthropods than CSG buffers, and (2) do crops adjacent to WSG buffers have greater numbers and diversity of arthropod natural enemies than crops adjacent to CSG buffers?

2. Methods

2.1. Study system

Study sites, distributed among 15 typical grain farms chosen from a list of CRP participating landowners in Caroline, Talbot, and Queen Anne's counties on the Eastern Shore of Maryland, were sampled over two years. Land use across these counties is very similar (Fig. S1), with less than 12% developed land in 2006 and a total 2010 population of 118, 646 (Fry et al., 2011; U.S. Census Bureau, 2010). Farmland, mostly row-crop agriculture and pasture on coastal plain sandy soils, comprised 58% of Caroline, 57% of Talbot, and 60% of Queen Anne's county in 2006 (Fry et al., 2011). This is interspersed by upland forest blocks and woody wetlands (Fig. S1, 2006 Caroline: 14% forest, 15% woody wetland; 2006 Talbot: 12% forest, 13% woody wetland; 2006 Queen Anne's: 12% forest, 14% woody wetland) (Fry et al., 2011). Sites were separated by > 2 km and surrounded by this similar landscape. At each site, warm or cool season grasses buffers, maintained for a