GfÖ Ecological Society of Germany, Austria and Switzerland

Basic and Applied Ecology 16 (2015) 531–543

Basic and Applied Ecology

www.elsevier.com/locate/baae

Plant composition modulates arthropod pest and predator abundance: Evidence for culling exotics and planting natives

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Received 26 August 2014; accepted 18 May 2015
Available online 23 May 2015

Abstract

We investigate the role of plant species in crops, pasture and native vegetation remnants in supporting agronomic pests and their predators. The study was conducted in three Australian States and across 290 sites sampled monthly for two years. Pastures played a key role in harbouring pest species consistent across States, while native vegetation hosted relatively more predators than other habitat types within each State. Furthermore, native plant species supported the lowest pest density and more predators than pests; in contrast, 75% of the exotic weed species surveyed hosted more pests than predators. Despite the role of pasture in harbouring pests, we found in NSW that pasture also supported the highest proportion of juvenile predators, while native vegetation remnants had the lowest.

Our results indicate that non-crop habitat (native remnants or pasture) with few exotic weeds supports high predator and low pest arthropod densities, and that weeds are associated with high pest densities. By linking broad response variables such as 'all pests' with specific predictors such as 'plant species', our study will inform on-farm management actions of which weeds to control and which natives to plant or regenerate. This study shows the importance of knowing the function of habitats and plants species in supporting pests and predators in agricultural landscapes across multiple regions.

Zusammenfassung

Wir untersuchen die Rolle, die Pflanzenarten auf Feldern, Weiden und in Fragmenten einheimischer Vegetation für den Erhalt von Schädlings- und Nützlingspopulationen spielen. In drei Australischen Staaten wurden 290 Standorte monatlich über zwei Jahre beprobt. Weiden spielten in allen Staaten eine Schlüsselrolle für die Schädlingsarten, während naturnahe Vegetation in jedem Staat relativ mehr Räuber beherbergte als andere Habitattypen. Einheimische Pflanzen unterstützten die geringsten Schädlingsdichten und mehr Räuber als Schädlinge. Im Gegensatz dazu beherbergten 75% der untersuchten exotischen Unkrautarten mehr Schädlinge als Räuber. Trotz der Bedeutung der Weiden für die Schädlinge fanden wir, dass in

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http://dx.doi.org/10.1016/j.baae.2015.05.005

New South Wales Weiden auch den höchsten Anteil von juvenilen Räubern beherbergten, während dieser in Fragmenten einheimischer Vegetation am geringsten war. Unsere Ergebnisse zeigen, dass naturnahe Fragmente und Weiden mit wenigen exotischen Unkräutern hohe Räuber- und geringe Schädlingsdichten unterstützen und dass Unkräuter mit hohen Schädlingsdichten assoziiert sind. Indem grobe abhängige Variablen, wie z.B. "Alle Schädlinge" mit spezifischen unabhängigen Variablen, wie z.B. "Pflanzenart" verknüpft werden, beeinflusst unsere Untersuchung Managementmaßnahmen vor Ort, wie z.B. welche Unkräuter bekämpft und welche einheimischen Arten gepflanzt oder regeneriert werden sollten. Unsere Untersuchung zeigt, wie wichtig es ist, Kenntnisse von der Funktion von Habitaten und Pflanzenarten für die Förderung von Schädlingen und Räubern in der Agrarlandschaft zu besitzen.

Keywords: Biological control; Ecosystem services; Habitat functionality; Integrated pest management; Pest suppressive landscapes; Revegetation; Sustainable farming

Introduction

Significant knowledge gaps exist in the management of arthropod pests and predators in agricultural landscapes, despite a long history of biological control research. In particular how, and when during their lifecycle, arthropods are using both crop and non-crop habitat. The consequences of such knowledge gaps mean that pest populations are currently allowed to build up on plants or in areas that are unmanaged (Kennedy & Storer 2000; Schellhorn, Glatz, & Wood, 2010), and move into crops, whereas predator populations may not perform well because they are living in landscapes where resources for their survival and effective biological control are limited (Landis, Wratten, & Gurr, 2000).

This study addresses some of these knowledge gaps in pest management, by increasing our understanding of the landscape context in which crops are grown and specifically investigating the plant species and habitat types associated with a wide range of pest and predator species. The current evidence points towards a positive association of natural enemies with non-crop habitat, but there is no consistent trend emerging for pests (see reviews by Bianchi, Booij, & Tscharntke, 2006; Chaplin-Kramer, O'Rourke, Blitzer, & Kremen, 2011; Veres, Petit, Conord, & Lavigne, 2013). For predators studies clearly suggest that their resources are present in non-crop habitats, but very few studies have sought to identify what the resources (i.e. plant species or taxa) might be, or the patch to patch variability of the resource (Bianchi, Schellhorn, & Cunningham, 2013; Bianchi et al., in press). For pests, the lack of a relationship with 'complex' landscapes (most often defined in terms of the proportion of non-crop vegetation, e.g. Rand, van Veen, & Tscharntke, 2012) suggests that their resources beyond the crop are not associated with a measure as coarse as land use or land cover types, but scattered over a wide range of habitats. Therefore, if landscape relationships exist with pest abundance as a whole, then it might be associated with resource patterns that occur at a finer spatial scale and distribution (i.e. at the host plant scale).

We know relatively little about the diversity of plants used by pests in intensive semi-arid agricultural systems across their life-span (Bianchi et al., 2013; Norris & Kogan, 2000; Panizzi, 1997; Schellhorn et al., 2010), how this varies between landscapes and geographic regions (Firempong & Zalucki, 1990), and why often highly mobile individuals move from one host plant to another. Furthermore, non-crop plant species may play an important role in sustaining pest populations, because crop plants are not always the preferred host (e.g. Firempong & Zalucki, 1990). Likewise, natural enemies of pests may consume both pest and non-pest herbivores on a range of crop and non-crop plant species (Dennis & Fry, 1992; Landis et al., 2000; van Emden, 1990) as well as use plant resources directly, such as nectar and pollen in non-crop habitats (Limburg & Rosenheim, 2001; Robinson, Jonsson, Wratten, Wade, & Buckley, 2008; van Rijn, Kooijman, & Wäckers, 2013).

This study makes the shift in emphasis from an ecological understanding of the importance of the landscape context to a set of management actions that will allow us to capture pest control services by understanding: (1) the resources used within habitat patches by multiple species of pests and predators, (2) if similarities occur across multiple species of pests that are managed by farmers and among species of predator that attack them, and (3) the variability of resource use across plant species, habitats, landscapes and regions (i.e. 'States' as we refer to the three study regions throughout). We asked: where are the adult and juvenile pests and predators of grain crops in the agricultural landscape? On which habitats, plant classes (such as native species, broad leaf weeds, and grasses) and plant species within remnant native vegetation patches are they found? Providing answers to these questions will provide guidelines for farmers as to which habitats and plant species to conserve as a means to support predators and which plant species to suppress as a means to minimize pest population build-up.

Materials and methods

Study region

We selected three distinct biogeographic regions dominated by grain production in southern New South Wales