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Agricultural land use affects abundance and dispersal tendency of predatory arthropods

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Abstract

Predatory arthropods contribute to biological control, but to become an integral part of agricultural management, it is essential to identify drivers of their spatio-temporal distribution at the landscape scale. This study focuses on how agricultural land use affects the community composition, emergence and dispersal tendency of predatory arthropods. The arthropods were collected in emergence traps during the growing season (14 weeks) in a gradient of agricultural land uses from intensively managed sugar beet fields, over winter wheat fields, to less intensively managed grasslands. The emergence traps were equipped with one pitfall trap and a collecting bottle at the top. The distribution of the arthropods between these two collecting methods was assumed to represent their tendency to move out of the habitat. The grasslands had the highest numbers of spiders, while the winter wheat fields had the highest numbers of omnivorous rove beetles and macropterous predaceous ground beetles. The phenology of emergence differed between the land-use types, resulting in seasonal differences in community composition. The overall dispersal tendency of predatory arthropods was higher in crop fields than in grasslands. This study suggests that only a diverse mix of agricultural land uses will provide high levels of predators from different functional groups, throughout the growing season.

Zusammenfassung

Epigäische Raubarthropoden tragen zur biologischen Schädlingskontrolle bei. Damit landwirtschaftliche Bewirtschaftungsmaßnahmen zur Förderung dieser Nützlinge führen können, ist es wichtig die Steuergrößen für die räumlich-zeitliche Verbreitung dieser Arten in der Agrarlandschaft besser zu verstehen. In dieser Studie wurde untersucht wie verschiedene agrarwirtschaftliche Landnutzungstypen die Gemeinschaftszusammensetzung, Emergenz und Ausbreitungstendenz adulter Raubarthropoden beeinflussen. Dazu wurden Raubarthropoden über 14 Wochen in intensiv bewirtschafteten Zuckerrüben und Weizenfeldern und in weniger intensiv bewirtschafteten Grünlandhabitaten mittels Emergenzfallen beprobt. Die Emergenzfallen nutzten eine Bodenfalle zum Fang der bodenaktiven Arthropoden und eine Sammelflasche am oberen Ende der Falle zum Fang aufsteigender Arthropoden. Das Verhältnis der Arthropodenzahl zwischen den beiden Fanggefäßen wurde als Maß für die Tendenz, das Habitat zu verlassen verwendet. In Grünländern wurden die meisten Spinnen gefangen, Weizenfelder hatten die höchste Anzahl an kleinen Kurzflügelkäfern mit verschiedenen Ernährungspräferenzen und makropteren, räuberischen Laufkäfern. Der zeitliche

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Verlauf der Emergenz unterschied sich zwischen den Landnutzungstypen, was zu Unterschieden in der Gemeinschaftszusammensetzung führte. Die Ausbreitungstendenz war auf Ackerflächen höher als auf Grünlandflächen. Diese Untersuchung zeigt, dass eine vielfältige Agrarlandschaft mit intensiv und weniger intensiv bewirtschafteten Landnutzungstypen, zu hohen Dichten aus verschiedenen funktionellen Gruppen und über die gesamte Wachstumsperiode beiträgt.

Keywords: Biological control; Emergence; Functional groups; Landscape; Natural enemies; Phenology

Introduction

Predatory arthropods contribute to biological control, an ecosystem service that may increase yields and reduce pesticide use (Bommarco, Kleijn, & Potts 2013). To improve biological control it is essential to identify factors influencing the spatio-temporal distribution of predatory arthropods at landscape scales (Bianchi, Booij, & Tscharntke 2006; Schellhorn, Bianchi, & Hsu 2014). Access to suitable overwintering sites is often regarded as a key factor affecting the size of predator communities and it is generally assumed that it is semi-natural habitats that act as overwintering sites (Pfiffner & Luka 2000) and serve as population sources for predatory arthropods (Wissinger 1997). However, predatory arthropods also overwinter in crop fields (Holland, Birkett, & Southway 2009), that consequently may act as important sources of predators (Rand, Tylianakis, & Tscharntke 2006), and make a substantial contribution to biological control when crop fields are the locally dominating land-use types. Hence, to promote biological control in agricultural landscapes we need a broader focus on different land-use types including cropped fields and their production of natural enemies (Palmu, Ekroos, Hanson, Smith, & Hedlund 2014).

Habitats with permanent vegetation and without tillage constitute important overwintering sites for predatory arthropods as they provide resources (Thomas, Mitchell, & Wratten 1992) and increase overwintering success (House & Parmelee 1985) by reducing direct mortality caused by tillage or habitat degradation (Holland & Reynolds 2003; Thorbek & Bilde 2004). Not only may the number of predators, but also the phenology, influence the biological control potential of predator communities. The time of emergence varies between different predatory arthropods (Jones, 1976) and thus community composition within a habitat will change over the season. Management affects some arthropod groups more than others (Thorbek & Bilde 2004), suggesting that phenological patterns may differ between communities in different land-use types, potentially affecting predator abundances and resource dynamics at landscape scales (Schellhorn, Gagic, & Bommarco 2015). The community composition of predatory arthropods may also depend on dispersal at a landscape scale (e.g. Bonte & Saastamoinen 2012). The tendency to disperse can increase with increasing population density; to avoid reduced individual fitness (Bowler & Benton 2005) or reduced habitat quality (Baguette, Clobert, & Schtickzelle 2011). Communities may thus differ in dispersal tendencies depending on land-use type. Semi-natural habitats are generally assumed to constitute important sources for predatory arthropods colonizing annual crops, though rarely empirically shown (Coombes & Sotherton 1986; Petersen 1999). However, predators actively move from crop fields to adjacent semi-natural habitats (Duelli, Studer, Marchand, & Jakob 1990; Macfadyen & Muller 2013) suggesting that crop fields act as important sources of predatory arthropods dispersing to natural habitats (Rand et al. 2006).

The aim of this study was to improve the understanding of spatio-temporal dynamics of predatory arthropods by studying how agricultural land use affects their community composition and tendency to disperse from the habitat. Predatory arthropods were sampled in emergence traps in agricultural land uses ranging from intensively managed sugar beet fields, over winter wheat fields to less intensively managed grasslands. The arthropods sampled in the emergence traps comprised overwintering adults and newly emerged individuals, including immature stages (e.g. spiders) but not larvae. The tendency to disperse from the habitat (hereafter dispersal tendency) was estimated for arthropods known to be able to move by active flight or ballooning. The ratio between the numbers of individuals caught in collecting bottles at the top of the traps to the numbers caught in pitfall traps at the soil surface was used as a proxy for dispersal tendency. We expected that the abundance of predatory arthropods would be reduced by intensive management, as it negatively affects species sensitive to tillage and reduces resource availability during winter. This will lead to differences in community composition depending on agricultural land-use type. Lastly, we expected that the dispersal tendency of predators would be higher in the most intensively managed land-use types due to lower habitat quality.

Material and methods

Study design

Field work was performed April–July 2011 in a landscape dominated by annual crops (77.0 ± 1.2% (mean ± SE) of the total area within a radius of 1000 m around the study sites) in an area covering approximately 850 km^2 of south-western