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Relative importance of management and natural flooding on spider, carabid and plant assemblages in extensively used grasslands along the Loire

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Abstract

In Europe, agri-environment schemes (AES) have been implemented to counteract the effects of agricultural intensification. Studies investigating the role of management improvement induced by AES are quite numerous, but rarely take into account the effect of natural perturbations such as flooding, although severe disturbances are well known to shape community structure. Here we investigated the relative importance of management improvement and flooding to explain community parameters of two dominant arthropod groups and vegetation in alluvial meadows.

Sampling took place in 2013, using suction samplers for arthropods and phytosociological relevés for vegetation, in 83 meadows distributed along 200 km of the Loire Valley (France). Pair-matched approach (by R-ANOVA) was used to assess overall effects of AES whereas a gradient analysis (GLM) was carried out to assess the impact of AES prescriptions (fertilisation and cutting-date) together with indirect (long-term) and direct (short-term) effects of flooding.

No significant effect of AES was found on arthropod and plant assemblages, abundance/productivity or diversity (both α and β), but the number of rare plant species was higher in sites under AES. Prescriptions had little impact on most response variables considered; the only significant impact being the positive effect of high-amounts of fertilisers on spider α- and β-diversities. Conversely, systematic long-term effects of flooding were found on all response variables of spiders, carabids and plants, underlining the key role of this factor in alluvial meadows. Our study demonstrates that maintaining or enhancing hydrological functioning of ecosystems is even more important than regulating both the cutting-dates and the low input of fertilisers for conservation purposes in flooded, already naturally nutrient rich, meadows.

Zusammenfassung

In Europa wurden Agrar-Umwelt-Programme (AES) begonnen, um den Einflüssen einer intensivierten Landwirtschaft entgegenzuwirken. Untersuchungen zu Verbesserungen durch AES sind recht zahlreich, aber selten berücksichtigen sie den Einfluss natürlicher Störungen (z.B. Überflutungen), obwohl schwere Störungen bekanntlich die Gemeinschaftsstruktur formen können. Wir untersuchten die relative Bedeutung von Verbesserungen durch Bewirtschaftung und Überflutung, um die Gemeinschaftsparameter von zwei Arthropodengruppen sowie der Vegetation in Flussauen zu erklären. Die Probenahmen erfolgten 2013 mit Saugfängen für Arthropoden und vegetationskundlichen Aufnahmen auf 83 Wiesen entlang eines 200 km-Abschnitts der Loire

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(Frankreich). R-ANOVA wurde benutzt, um die globalen Effekte von AES abzuschätzen, während Gradientenanalysen durchgeführt wurden, um den Einfluss von AES-Vorschriften (Düngung und Mähzeitpunkt) zusammen mit indirekten (langfristigen) und direkten (kurzfristigen) Effekten der Überflutung zu bestimmen. Wir fanden keinen signifikanten Effekt von AES auf die Arthropoden- und Pflanzengemeinschaften, auf Abundanz/Produktivität oder α- oder β-Diversität, aber die Anzahl seltener Pflanzenarten war unter AES erhöht. Die Vorschriften hatten wenig Einfluss auf die meisten der untersuchten abhängigen Variablen; der einzige signifikante Einfluss war der positive Effekt von Düngung auf die α- und β-Diversität der Spinnen. Umgekehrt fanden wir, dass systematische Langzeiteffekte der Überflutung bei allen die Spinnen, Laufkäfer und die Vegetation betreffenden abhängigen Variablen auftraten, was die Schlüsselrolle dieses Faktors in Flussauen unterstreicht. Unsere Untersuchung zeigte, dass Erhalt oder Stärkung des hydrologischen Funktionierens von Ökosystemen noch wichtiger ist, als für Naturschutzzwecke Mähzeiten und Düngergaben in ohnehin nährstoffreichen überflutungswiesen zu regulieren.

Keywords: Coleoptera Carabidae; Araneae; Stochastic disturbance; Cutting-date; Fertilizers

Introduction

Over the last decades, agricultural intensification has accelerated adverse effects on wildlife (Millennium Ecosystem Assessment 2005). In Europe, agri-environment schemes (AES) have been implemented to counteract these effects by providing financial incentive for farmers to adopt extensive agricultural practices. Farmers involved in AES preferentially engage fields which are less suitable for intensive farming (Kleijn & van Zuijlen 2004), explaining why semi-natural grasslands are especially targeted by AES.

Investments in AES were substantial, with for example 34.9 billion Euros provided for 2007–2013 programmes (COM 2008). They currently cover 21% of all farmlands in the 27 EU countries. Despite these high financial inputs, AES seem to have contrasting successes (Kleijn et al. 2006), depending on the AES type and the model studied. For example, AES are recognised to have positive effects on birds in the UK (Brereton, Warren, Roy, & Stewart 2007) and on pollinators in Switzerland (Albrecht, Duelli, Muller, Kleijn, & Schmid 2007). However, AES also prove damaging when poorly designed or when targeting single taxon (Konvicka et al. 2007). Results on plant diversity are usually reported to be positive (e.g., Critchley, Walker, Pywell, & Stevenson 2007; Kleijn, Berendse, Smit, & Gilissen 2001). Monitoring and evaluating these schemes is imperative to improve their efficiency and maximise the conservation outcomes.

Evaluation of AES impact has usually focused on birds (Kleijn et al. 2001, 2006; Marshall, West, & Kleijn 2006) and vegetation (Critchley et al. 2007) mainly because they are the main targets of AES as arthropods are often neglected in biodiversity conservation policies (e.g., Cardoso, Erwin, Borges, & New 2011). Nevertheless, some studies also dealt with arthropods – mainly bees and grasshoppers (Kleijn et al. 2001; Knop, Kleijn, Herzog, & Schmid 2005), and found positive effects of AES. Despite their recognised indicator value in agricultural landscapes, predator arthropods like spiders and carabid beetles remain relatively less studied in the context of AES compared to other taxa.

Flooding is a key driver of intertidal and riparian ecosystems, and particularly of arthropod communities (Desender & Maelfait 1999) and vegetation (Violle et al. 2011). Arthropod communities of European rivers are likely to use a 'risk strategy' to survive in this naturally disturbed habitat. The strategy consists of a suite of life history traits such as high productivity ('r-strategy'), high capacity for dispersion, and active recolonisation from areas that have been sheltered from flooding (Zulka 1994). Vertical emigration to uplands or higher vegetation is also expected to increase recolonisation success (Adis & Junk 2002). A few terrestrial species also withstand short to prolonged (up to several weeks) periods of submersion (e.g., insects: Hoback & Stanley 2001, spiders: Pétillon, Montaigne, & David 2009). Conversely, flood events can be seen as a way to colonise new habitats and exchange individuals between distant populations (Lambeets, Breyne, & Bonte 2010), possibly enhancing among-site diversity in the long term. In the short-term, flood events strongly reduce local diversity. Floodplains are generally characterised by a low percentage of stenotopic species (Lafage, Papin, Secondi, Canard, & Pétillon 2015). Specialist species with adaptations to flooding are found in more regularly flooded habitats like gravel banks (Lambeets, Vandegehuchte, Maelfait, & Bonte 2008) or salt marshes (Pétillon, Potier, Carpentier, & Garbutt 2014).

No study has assessed the relative effects of AES vs. stochastic disturbances induced by flooding in such ecosystems, yet their expected effects on biodiversity are potentially opposite. Consequently, no or few effects of AES in shaping arthropod and plant assemblages are expected in floodplains. To test this hypothesis, we evaluated the role of AES and flooding in explaining α and β diversities, abundances (biomass for plants), species rarity and assemblage composition of two non-target groups (spiders and carabids) and vegetation in the flooded meadows of the Loire River (France). For spiders and carabids, analyses of rarity were not performed because of the lack of proper national or regional statuses of rarity (the English classification cannot be applied here: Pétillon, Courtial, Canard, & Ysnel 2007), and also