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Environmentally friendly management as an intermediate strategy between organic and conventional agriculture to support biodiversity

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ABSTRACT

Farmland biodiversity dramatically declined in Europe during the 20th century. Agri-environment schemes (AES) were introduced in the late 1980s in European Union countries as a solution to combat biodiversity decline. We examined the effectiveness of AES in enhancing biodiversity in a new EU member country (Estonia) over the period of 2010–2012. We compared species numbers and abundance of bumblebees and birds, plus cover of flowers, between three farming systems in two regions of Estonia. Farm types included conventional and two under AES (organic and a less strict environmentally friendly management agreement). Environmentally friendly management practices in Estonia include diversified crop rotations, at least 15% of arable land (including rotational grasslands) under legumes, permanent grassland strips, protection of landscape elements, reduced applications of agrochemicals, etc. The two selected regions (North and South) differed in landscape structure, soil types and crop yields. Flower cover and bird species richness and abundance without the dominant species (skylark) were higher on organic farms. Bumblebee species richness was significantly higher under both types of AES than under conventional farming. Flower cover, abundance and species richness of bumblebees and birds were significantly higher in the more heterogeneous landscapes of Southern Estonia. Environmentally friendly management may be a viable alternative to organic farming for a widely accepted, simple but large-scale greening of agricultural landscapes.

1. Introduction

Modern agriculture significantly adversely impacted farmland biodiversity in Europe during the 20th century (Stoate et al., 2009; Potts et al., 2010; Tscharntke et al., 2012). 300 million farmland birds have been lost from the continent since 1980 (Birdlife, 2012). The main reasons attributed for the loss of farmland biodiversity were intensification of agricultural practices that have resulted in loss of non-cropped habitat elements, land use changes, increased use of pesticides and fertilizers and more mechanisation (Donald et al., 2006; Butler et al., 2007; Gill et al., 2012). Intensification of agricultural production is a process largely driven in the European Union (EU) by the Common Agricultural Policy (CAP) (Donald et al., 2002; Pe'er et al., 2014). Agri-environment schemes (AES) were introduced in a few EU member states in the late 1980s as a tool to address the negative environmental impacts of agricultural intensification, including the decline in biodiversity (Tscharntke et al., 2011). Since 1992 AES became mandatory for all EU member states, including those mainly from Eastern Europe that joined the EU in 2004 (European Commission, 2005).

Although the effectiveness of AES in biodiversity protection has been questioned across the whole EU (Kleijn and Sutherland, 2003; Hole et al., 2005; Kleijn et al., 2011), there is evidence of a positive influence of several schemes on biodiversity (e.g., review on organic farming in Bengtsson et al., 2005; Tuck et al., 2014). Targeted and exacting schemes accompanied by sufficient support perform well for biodiversity (most recently e.g., Perkins et al., 2011; Baker et al., 2012), especially in more intensively farmed areas (Carvell et al., 2011). Lack of targeting in implementation of AES could therefore be one reason for poor performance (Elts and Lõhmus, 2012).

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Tscharntke et al. (2005, 2012) hypothesised that AES across multiple fields and farms may contribute to conservation, at least in simple landscapes. Large-scale implementation of AES has been recommended for enhancing biodiversity (McKenzie et al., 2013). Two broad strategies for AES implementation have been considered: deep and narrow (targeted and demanding) versus broad and shallow (widely implemented, relatively simple). The relative merits of different AES implementation in various landscapes and for a diversity of taxa have yet to be confirmed. Most studies of AES compare only two management systems, i.e. farms with and without an AES contract, including those under organic and conventional farming (but see Davey et al., 2010; Baker et al., 2012; Elts and Lõhmus, 2012).

Conservation effectiveness of AES further depends on landscape characteristics, land use context and taxa of organisms studied. Based on reviews by Kleijn et al. (2011) and Tscharntke et al. (2012), conservation effectiveness of AES is lower in complex agricultural landscapes with a high proportion of non-cropped habitats (>20%) than in homogenous landscapes. According to the landscape-moderated conservation hypothesis (Tscharntke et al., 2005), landscape heterogeneity might outweigh the beneficial effect of AES in complex landscapes. Tuck et al. (2014) found that organic farming has a greater benefit on biodiversity in landscapes with higher land use intensity. Batáry et al. (2011) in their meta-analysis showed differential effectiveness of AES for arable and grasslands as well as for different functional species groups.

Critically, most evidence on the performance of various types of AES comes from Western European countries while studies from the East (i.e. new member states) are largely lacking (Uthes and Matzdorf, 2013). Systematic biodiversity monitoring is not performed in all countries and is largely missing for new member states (L. Sutcliffe submitted manuscript).

Estonia joined the EU in 2004, but started experimentation of AES on pilot areas in 2000. The objectives of the Estonian AES are to: promote the implementation and continuous use of environmentally friendly management methods in agriculture; preserve and increase biological and landscape diversity; help farmers act in an environmentally favourable way whilst maintaining an adequate income; increase environmental awareness (Estonian Rural Development Plan 2007–2013, 2009). The support for organic farming and environmentally friendly production was rolled out nationally from 2004 (Estonian Rural Development Plan, 2005a). The environmentally friendly production scheme was newly developed and not copied from existing Western European AES. Since 2009 the two Estonian AES were modified, with the requirements for organic farming simplified and those for environmentally friendly production made partly stricter. The fulfilments for organic farming are similar to those found elsewhere in the EU and mainly restrict the use of synthetic pesticides and mineral fertilizers (Eur-Lex, 2007). For the environmentally friendly management scheme, requirements that potentially benefit farmland biodiversity include: limitations on the use of pesticides and growth regulators; diversified crop rotations; protection of landscape elements; minimum share of arable land (including rotational grasslands) under legumes and permanent grassland strips (see more details in Supplementary online material 1). Farmland area in Estonia currently enrolled under an AES stands at 13.7% for organic and 40.6% for environmentally friendly management (Agricultural Research Centre, 2013).

This is the first multi-year study that evaluates the ecological effectiveness of environmentally friendly farming as an intermediate state between organic and conventional farming in terms of level of requirements and uptake rate. We investigated the effectiveness of Estonian AES in benefitting three taxonomic groups (plants, bumblebees and birds) from 2010 to 2012. Three types of farming systems were compared: farms with organic AES contracts; farms with environmentally friendly management AES contracts; farms without AES contracts (control group, conventional). We hypothesised that: (i) all biodiversity metrics are higher with organic and environmentally friendly management than conventional farming, and highest on organic farms with the most stringent AES requirements; (ii) the effects of AES are more pronounced in regions with relatively simple landscape diversity and high production intensity than in those with more heterogeneous landscapes and lower production pressure; and (iii), effects of AES are more apparent for plants than for mobile taxa such as bumblebees and particularly birds. We expected that because of the mobility of organisms, environmental factors outside the study sites were likely to additionally affect populations (Ekroos et al., 2010). Testing potential differences between land use types (predominantly arable crops or grassland) was not possible because all the monitored farms had both.

2. Material and methods

2.1. Monitoring areas

Biodiversity data were collected as part of the ongoing evaluation of AES done in the framework of the Estonian Rural Development Plan 2007–2013 (Agricultural Research Centre, 2013). Flower cover was estimated and bumblebee and bird counts conducted in two regions of Estonia: Jõgeva, Järva and Lääne-Viru counties (hereafter Northern Estonia, centre coordinates 59°4′N; 26°12′E) and Valga, Võru and Põlva counties (hereafter Southern Estonia, centre coordinates 57°52′N; 26°57′E). Regions were selected based on the differences in landscape structure, farmland composition, intensity of production and AES uptake. Northern Estonia (total area 8666 km^2) is characterised by large fields with spring barley, spring and winter wheat and spring rape the dominant crops, and high yields by Estonian standards (average cereal yield for 2004–2013 was 3011 kg/ha). 6% of the Northern region's agricultural area was under organic farming and 55% under environmentally friendly management during the monitoring period (Agricultural Research Centre, 2013). Southern Estonia (6480 km^2) has a relatively diverse landscape, with spring wheat, spring rape and oat the dominant crops, and lower yields (average cereal yield for 2004–2013 was 2792 kg/ha; Agricultural Research Centre, 2013; Statistics Estonia, 2014). 15% of the Southern region's agricultural area was under organic farming and 39% under environmentally friendly management (Agricultural Research Centre, 2013).

In both region, 33 farms were monitored: 11 organic farms, 11 environmentally friendly management farms (both have 5-year AES obligation) and 11 without AES contracts (conventional farms) – 66 in total (Fig. 1). Conventional farms have to follow only cross-compliance requirements. Cross-compliance is a policy mechanism that requires farmers receiving direct payments of the so called Pillar 1 of the Common Agricultural Policy to comply with; basic standards concerning the environment, food safety, animal and plant health and animal welfare; maintaining land in good agricultural and environmental condition. The environmentally friendly management AES consists of two tiers: the basic level (EFM1) and the additional level (EFM2; Supplementary online material 2). Due to low uptake of EFM1 (*ca* 7% of agricultural land in Estonia is under this support) and lack of financial resources for monitoring, only EFM2 farms were included in this study (*ca* 41% of total farmland area under this scheme). EFM2 requirements include: limitations on the use of pesticides and growth regulators; diversified crop rotations; protection of landscape elements; minimum share of arable land (including rotational grasslands) under legumes (15%) and permanent grassland strips (2–5 m wide; see more details in