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Applying trait-based community metrics of relevance to conservation for understanding community patterns of farmland birds in Northwest Russia

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ABSTRACT

Use of community trait-based metrics has been increasingly implemented for achieving an integrated view of biodiversity in conservation planning. We examined the extent, to which the use of community metrics based on species traits reflecting plausible sensitivity to change would contribute to our understanding of landscape characteristics of importance to the conservation of farmland birds in a poorly studied region of Northwest Russia. We collected species data on farmland from 230 transects covering a total 215 km for each year of 2008, 2010 and 2011 and analysed them using generalised linear mixed modelling. We derived community indices from species traits of habitat specialisation, trophic position, relative brain size and body mass. By relating these indices to the numbers of all species regarded farmland and Species of European Conservation Concern (SPEC), and by analysing them against the type of field and occurrence in typical non-cropped landscape elements, we showed consistent, albeit weak, congruence among the taxonomic and trait-based community descriptors. All community descriptors had their lowest estimates in arable fields. Community specialisation was the highest in open abandoned fields, which confirms the importance of such fields as refuges for regionally specialised species. Pastures were characterised by the highest community biomass, which indicates a particularly good resource base. Presence of ditches, of all non-cropped elements, had the strongest positive relationship with the community descriptors. The SPEC number strongly correlated with the overall species richness of farmland birds. A relatively weak congruence between taxonomic and trait-based community descriptors highlights their complementarity in understanding the underlying mechanisms of community changes. However, similarity in patterns among field types means that, under the current level of production in the region, accounting for the species richness of farmland birds seems to be sufficient to rapidly assess community sensitivity to agricultural change.

1. Introduction

Considerable progress has been made describing biodiversity patterns in agricultural environments with the objective of understanding which biodiversity components are retained despite agricultural expansion and intensification within landscapes and why (Norris, 2008). Accounting for ecological differences among species is increasingly used in conservation planning aiming at an integrated view of biodiversity. Functional indices such as functional richness, functional evenness or functional divergence (Mason et al., 2005) based on species-traits as well as indices of community-level weighted means of trait values are used to complement the taxonomic community metrics (e.g. Devictor and Robert, 2009; Guerrero et al., 2011).

Patterns obtained from taxonomic community metrics and trait-based ones for birds in agricultural landscapes may not be congruent. In France, the taxonomic, functional (i.e., based on traits such as species specialisation) and phylogenetic diversity metrics of the of avian communities only partly correlated at national scale (Devictor et al., 2010). Intensity of agricultural land use had differential effects on community taxonomic diversity and on community specialisation and trophic indices (Filippi-Codaccioni et al., 2010; Teillard et al., 2015). The presence of non-cropped elements in farmland promoted

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community species diversity but not community specialisation (Chiron et al., 2010; Filippi-Codaccioni et al., 2010). This raises the question of the complementarity of these indices and their use in conservation assessments.

Environmental or land-use changes exert varied amounts of pressure on species populations in accordance with species ecological characteristics making some species prone to decline under environmental change or disturbance (e.g. Devictor and Robert, 2009; Jennings and Pocock, 2009). Bird species were shown to be of particular sensitivity to change if they are specialised in habitat use and diet, are long-distance migrators, have relatively short incubation and fledging periods and relatively small brain size (Amano and Yamaura, 2007; Doxa et al., 2012; Filippi-Codaccioni et al., 2010; Le Viol et al., 2012; Pocock, 2011; Princé et al., 2013; Shultz et al., 2005).

Models derived for habitat association (Whittingham et al., 2007) and relationships between species traits and population trends developed in one region can be poor at inferring patterns in another region (Le Viol et al., 2012; Pocock, 2011), especially if the regions vary considerably in the dynamics of land-use changes (Sutcliffe et al., 2014). Regional studies are therefore necessary for enabling comparisons of patterns in order to assess the implied mechanism in the biodiversity responses (Pocock, 2011) and developing regional land-use strategies (Sutcliffe et al., 2014).

Research on farmland biodiversity in Eastern and Southern Europe has intensified in recent decades (Sutcliffe et al., 2014) but remains infrequent in the European part of the Russian Federation. In the 20th century, state-controlled agriculture was practiced on large fields fit for use by large production units (Liefert and Liefert, 2012), yet it never reached the levels of intensity typical of European Union production driven by the market economy and output-based subsidies (Bokusheva et al., 2012). The agricultural landscape is a mixture of field types, many under low-input use, and it is rich in non-cropped elements such as ditches and scrub. In recent decades, a revival of agricultural production has been documented in the country (Guzel, 2012). Its further intensification is supported by the state (Griewald et al., 2017) and by a growing demand for land-based biomass (Norris, 2008). Therefore, agriculture-supported habitats in the region are presently susceptible to intensification pressures that have driven wide-scale biodiversity losses elsewhere in Europe (Stoate et al., 2009). Understanding the relationships between habitat characteristics and sensitivity of the biota is a prerequisite for providing an 'early warning' system in an agriculturally important region facing intensification.

We used data on farmland bird species recorded in fields across an agricultural landscape in Northwest Russia in order to examine the extent, to which the use of community metrics based on species traits reflecting plausible sensitivity to change would contribute to i) rapid assessment of the community sensitivity to change across the land-use types in comparison to taxonomic indices and ii) to understanding of the reasons for certain characteristics of an agricultural landscape, such as field types or non-cropped elements, being of importance to the conservation of farmland birds. The traits were specialisation to habitat, trophic position, brain size and body mass. The metrics derived from each trait were community weighted mean indices and abundance of the top quartile (i.e. 25% of top values) of the traits. The taxonomic metrics were the number of farmland bird species and Species of European Conservation Concern (SPEC).

2. Material and methods

2.1. Study area

We carried out research in the Gatchinsky administrative district of Leningrad region in Northwest Russia (59° 30′ N, 30° 2′ E; Supplementary material, Fig. A1). The region lies in the hemiboreal zone of Europe and occupies an area of 175 116 km^2. Forests make up about 65% of the district's area, farmland 28%, settlements 6% and wetlands 1%. In the northern part of the district, the soils are of a carbonate Ordovic type and have good natural drainage allowing for large fields within an open landscape. The south has mainly sod-podzolic soils with poor drainage and excess wetness, resulting in small fields fragmented by forest (Herzon et al., 2014). During the study, farmland consisted of 90 km^2 of arable crops, 230 km^2 of grassland used for hay, 50 km^2 of pastures used for cattle and 80 km^2 of fallows and abandoned fields.

Agriculture is the dominant economic activity and is practiced on 450 km^2 of land, of which 344 km^2 is arable (including sown grassland). Dairy is the main agricultural production line. Due to the district's importance as the main supplier of agricultural produce to St Petersburg, the regional production output is above the national average (Federal State Statistics Service, 2016; Supplementary material, Table A1). In terms of output in 2010, it was less productive than the Western European average (FAOSTAT, http://faostat3.fao.org; Supplementary material, Table A1) but comparable to that in Northern Europe (ibid.). There are no data on grassland use in the region but, according to our observations, it had several extensive features: grazing unimproved, mainly alluvial, grasslands and a single haymaking event were common, while intensive rotational grazing was rare.

2.2. Sampling protocol

We surveyed birds in 2008, 2010 and 2011 in a sample of 230 fields out of a total of 1224 fields (Herzon et al., 2014; Supplementary material, Table A2). We sampled survey fields randomly stratified by field type, so that the field types were represented in relation to their occurrence in the district. The numbers of the different field types slightly varied year on year due to crop rotations (Table 1). We placed one transect in the middle of each field along its longest side and crossing the opposite field edges. This resulted in 215 km of transects across 110 km^2 of field. No two transects were closer than 500 m from each other. We ran two counts in a season, with the central dates of mid-May and mid-June, from 7 a.m. to 11 a.m. under appropriate weather conditions. Small passerines were registered within a 50 m belt, while Corvidae and non-passerines were registered within a 250 m belt. Individuals foraging fields and hunting overhead (such as raptors and the barn swallow (*Hirundo rustica*)) were counted but birds passing high overhead were not. Surveys were undertaken each year by the same three fieldworkers, who are professional ornithologists and underwent training in describing agricultural habitats prior to the survey.

Table 1
Description of explanatory variables used in modelling the avian community in the agricultural landscape in Northwest Russia (n = 690 with 230 fields surveyed every year).

Explanatory variables	Description[a]
Dominant field type	Four classes: Arable land, n = 65, 61, 53; abandoned land, n = 18, 14, 12; grassland, n = 122, 132, 139; pasture, n = 25, 23, 26.
Year	Three classes: 2008, n = 230; 2010, n = 230; 2011, n = 230.
Ditches	Three classes: No ditches, n = 318; ditches around the field, n = 287; ditches within the field, n = 85.
Bushes	Three classes: No bushes, 345; only along ditches or by stone heaps, n = 299; within field area, n = 46.
Stones	Three classes: No stones in the field, n = 339; a few stones in the field; n = 237; numerous stones in the field, n = 114.

[a] The number of fields within each type varied from year to year due to crop rotations or change in use.