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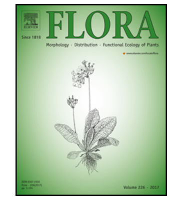

Man-made perching sites – electricity pylons accelerate fleshy-fruited plants succession in farmlands

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ABSTRACT

Electricity pylons and power lines in an agricultural environment serve as artificial perching sites for many birds. For this reason, seeds of fleshy-fruited plant species are predominantly deposited in these places. In the present study we show that electricity pylons may play an important role in the succession of fleshy-fruited shrubs and trees in intensive farmland. The aim of the study was to evaluate the importance of electricity pylons as artificial perching sites and thus as important locations enabling earlier succession and colonisation by fleshy-fruited plant species. The study was conducted during June and July 2013 in the Wielkopolska province of western Poland in intensive farmland with numerous small isolated forest patches. In total, we found 22 fleshy-fruited and 10 dry-fruited tree and shrub species under electricity pylons, of which 30% were alien species. The density of fleshy-fruited species under pylons was significantly higher in comparison with control plots, in which 85% of tree and shrub species were alien species. *Padus serotina* and *Sambucus nigra* were the species most frequently found under pylons. Plants of non-endozoochorous origin (i.e. anemochorous *Pinus sylvestris*, *Betula pendula*) were fewer in number. As a result, the share of fleshy-fruited species was much greater than those of wind-dispersed pioneer species. This is because fleshy-fruited species are able, thanks to artificial perching sites, to appear earlier than they would under natural conditions, in which these species follow the expansion and development of pioneer anemochorous species acting as natural perching sites. The presence of the electricity pylons compensates for a lack of natural perching sites in a homogenous landscape under intensive agriculture.

1. Introduction

Sites where birds can perch and roost also serve as defecation sites (McDonnell and Stiles, 1983). In semi-natural habitats, sites such as woodlots, bushes, and solitary trees are important for birds as well as important places for the growth of seedlings of many fleshy-fruited species, native and alien alike (Bonilla and Pringle, 2015). Such natural perching sites, usually pioneer trees and shrubs (e.g. *Betula* sp., *Pinus sylvestris*), are important for the continued succession of fleshy-fruited species (Kollmann, 1995; Kollmann and Schneider, 1999; Herrera and García, 2009) in wastelands, which occurs several years after the expansion and development of pioneer species. Agricultural intensification and the resulting homogenisation of the landscape leads to the destruction of many marginal habitats, e.g. wastelands with solitary trees and woodlots, with negative effects on farmland biodiversity (Robinson and Sutherland, 2002; Kleijn et al., 2006). The loss of such semi-natural habitats affects birds (Donald et al., 2001), insects (Weibull et al., 2003), and plants (Gabriel et al., 2006; Roschewitz et al., 2005; Kurek et al., 2015, 2016a).

One type of man-made structure found in intensive farmland is the electricity pylon, which plays a significant role in enhancing avian diversity (Tryjanowski et al., 2014). Electricity pylons, because they act as excellent perching sites, are focal places for the dispersal of endozoochorous plants in agricultural environments (Kurek et al., 2015). The linear structure of electricity pylons running through an intensively used landscape contribute to making them important places for perching birds. Electricity pylons can play the same role as single trees in mixed habitats visited

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occasionally by birds and mammals (Kollmann, 1995; Kollmann and Schneider, 1999; Herrera and García, 2009). Therefore the high density and species diversity of birds visiting and perching on electricity pylons increase the probability of seed deposition and seedling growth of many native and alien fleshy-fruited plant species.

The aim of the present study was to evaluate the importance of electricity pylons as artificial perching sites and thus as places enabling earlier succession and colonisation by fleshy-fruited species. We established the following hypotheses: 1) electricity pylons modify the course of succession of shrubs and trees, promoting more rapid settlement of fleshy-fruited species in homogenised intensive farmlands; 2) the area under electricity pylons in intensive farmland are the only suitable sites for shrubs and trees, including alien species; 3) the number and abundance of individual tree and shrub species differ under pylons in meadows as opposed to arable land; and 4) diversity of fleshy-fruited species under pylons depends on distance to the nearest source of diaspores and it is limited by herbaceous plants cover.

2. Materials and methods

The study was conducted during June and July 2013 in the Wielkopolska province of western Poland (centred on 52°N 16°E). The study area was situated near Odolanów city. The landscape was dominated by fields characterised by intensive agriculture, interspersed with numerous small isolated forest patches. By *intensive farmland*, we mean dominance of arable land and meadows over non-productive land. The main crops were cereals and maize. Meadows occurred on humid soils and in the flood plains of river valleys (for details see Tryjanowski, 1999). Soil moisture was the major determinant of herb layer composition, which varied from phytocenoses dominated by *Festuca ovina* s.l. (drier habitats with more sandy soils) to those dominated by *Phragmites australis* (humid habitats with more organic soils).

The study was carried out under three types of power lines located in open fields. Each type of pylon was characterised by a different basal area of the pylon: 110 kV–6 m^2, 220 kV – 21 m^2, 400 kV – 32 m^2. We randomly chose three power lines running across the study area and surveyed 116 electricity pylons (56 of 110 kV, 30 of 220 kV, and 30 of 400 kV). Reference plots in the same basal area were located 100 m away, under power lines between pylons in open fields. The number of individual shrubs and trees (i.e. genets, since shrubs and trees in the study area were exclusively of generative origin) was counted in each of the 116 pylon plots and the obtained density was standardised per square metre. Regardless of the type of fruit, all shrubs and trees were recorded (fleshy- and dry-fruited; endozoochorous and representative of other dispersal modes). In the analysis we also included the fleshy-fruited species as *Bryonia alba*. Distances from pylon plots to forest edges (woodland of at least 1 ha) and human settlements (villages, but also isolated houses including barns, yards, orchards) were estimated using the national database Geoportal (www.geoportal.gov.pl). Herbaceous plant species cover (at 10% intervals), species number, and height were also estimated. To obtain the mean height of herbaceous plants in each plot we measured the height of plants that formed dense cover of the community (mean value from five measurements in the corners and in the middle of the plot). Plant nomenclature follows Mirek et al. (2002).

3. Statistical analysis

For each pylon plot, the total number of recorded individual trees and shrubs was divided by the basal area of the pylon to produce a standardised measure of plant density per square metre. Chi-square contingency tests were used to compare the density of fleshy-fruited species between pylons and control plots. Prior to statistical tests, the data were transformed logarithmically to obtain a normal or at least symmetric distribution. To standardizing explanatory variables we used Z-score function. We used a multiple regression model to explain five explanatory variables, i.e. distance to the nearest woodland, distance to the nearest human settlement, percent of herb cover, height of herb cover, and number of herbaceous species, on the response variable, i.e. the species density of fleshy fruited trees and shrubs. We used the same model on the response variable, i.e. the species density of alien and native trees and shrubs. Multicollinearity of the explanatory variables in all regression models was not excessive (variance inflation factor (VIF) < 10). We used a two-sample test to compare the densities of alien and native plant species under pylons surrounded by arable fields ($n = 73$) with species under pylons surrounded by a meadow ($n = 43$). Using CANOCO 5.0, a canonical correspondence analysis was conducted to relate the abundance of individual species to pylons in meadows vs in arable fields. We performed the same analysis separately for dry- and fleshy-fruited species as well as for alien and native species.

4. Results

We found a total of 22 fleshy- fruited and 10 dry-fruited trees and shrub species (among dry-fruited species, eight were anemochorous and two synzoochorous) under electricity pylons, of which 30% ($n = 10$) were alien species. We recorded 6038 fleshy-fruited (99% of the total), 53 anemochorous (0.86%), and 4 synzoochorous (0.06%) individuals of trees and shrub species under pylons, compared to only 11 fleshy-fruited (85% of the total), one anemochorous (7.5%), and one synzoochorous (7.5%) individuals in control plots. *Padus serotina* and *Sambucus nigra* were found most frequently under pylons (Appendix A).

Under pylons surrounded by meadows, we recorded 900 individuals representing fleshy-fruited trees and shrubs (14 species) and 13 individuals representing dry-fruited trees and shrubs (7 species). Dominant herbaceous plant species were *Phragmites australis*, *Cirsium oleraceum*, *Urtica dioica* and *Phalaris arundinacea*. In the case of pylons surrounded by arable fields, we recorded 5138 individuals representing fleshy-fruited trees and shrubs (19 species) and 44 individuals representing dry-fruited trees and shrubs (5 species). Under pylons surrounded by arable fields, the dominant herbaceous plant species were *Holcus lanatus*, *Galium aparine*, *Aethusa cynapium*, *Cirsium arvense* and *Anchusa arvensis*.

The density of fleshy-fruited species under pylons was significantly higher in comparison to control plots ($\chi^2 = 1654.2$, df = 1, $p < 0.001$). Alien plant species represented 85% of the fleshy-fruited species. *Padus serotina* and *Sambucus nigra* were the species most frequently found under pylons, while the share of other species was very low (< 0.4%). The frequencies of all recorded tree and shrub species under pylons and in control plots are presented in Appendix A.

The multiple regression model explained significant variations in the density of fleshy-fruited species (Table 1, $R^2 = 17.5\%$, $F_{5,110} = 4.85$, $p < 0.0001$), which declined along with the percent cover of herbs (-0.194 ± 0.053, $p < 0.001$). The model for the density of alien (Table 2, $R^2 = 27.3\%$, $F_{5,110} = 8.27$, $p < 0.0001$) and native (Table 3, $R^2 = 16.8\%$, $F_{5,110} = 4.44$, $p < 0.0001$) species was significant. The density of alien species declined along with the percent cover of herbs (-0.229 ± 0.065, $p < 0.001$), distance to human settlement (-0.188 ± 0.066, $p = 0.001$), and height of herb cover (-0.200 ± 0.068, $p = 0.004$). In the case of the density of native species, only percent cover was significant (-0.212 ± 0.050, $p < 0.001$).