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Bird species number in farmland: interactions between point counts number and landscape structure

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Abstract. The aim of the study was to determine the relation between landscape structure, point counts number and the number of breeding bird species occuring in different types of farmland. Species number was evaluated using point counts on six plots localised in Polish and German farmland (from 30–52 points/plot, 10 min/point, radius — 100 or 150 m). The equation: $S = cA^z$, where S — species number, A — sample size (number of points), c, z — parameters, was used to test the relation between point counts number and species numbers. The coefficients of determination amounted to 0.95–0.99. Among the parameters of equation, c was more strongly correlated with landscape parameters (e.g. wood cover). The analysis revealed, that unified farmland requires bigger representative sample size compared to other, more diversified types of farmland. At least 50 points are needed for proper comparing bird species number between farmlands or periods.

Key words: farmland, landscape structure, point counts method, species-area curve, species richness

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INTRODUCTION

In spite of an advancement of research on the ecology of farmland birds in Poland during the last several years (Górski 1988, Kot 1988, Jermaczek & Tryjanowski 1990, Kujawa 1994, Tryjanowski 1999), the amount of data is insufficient. Tomiałojć (1997) has proposed to start monitoring of birds just in farmland. One of the regarded methods is point counting.

Agricultural landscapes are shaped by natural condition as well as by strong human influence. In a result they differ markedly between regions. However, the structure of vegetation cover changes rapidly from year to year. It is the source of serious difficulties with defining a key factors which affect the differences in bird richness and abundances if the results from different regions or periods are compared on the base of too small sample size. Number of species recorded strongly depends on the sample size. The relation between species number and sample size (area or number of samples) is often described by the equation: $S = cA^z$, where S — number of species, A — size of plot and c, z — parameters (e.g. Rosenzweig 1996, and especially to farmland birds see Tryjanowski 1999).

The aim of the study was:

— to verify whether in various agricultural landscapes the relation between number of points (A) and the number of breeding bird species (S) fit to the model above;

— to show the influence of landscape structure on the relation above;

— to investigate some methodological problems linked to the impact of landscape structure on relation between sample size and species number.

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STUDY AREA

The study was carried out in two typical lowland agricultural regions in Central Europe: in western Poland (General D. Chłapowski Landscape Park, 50 km south of Poznań) and in northern Bavaria, Germany (valley of Main river near town Knetzgau). Land-use type in both study areas is similar. About 80% of the area consists of crop fields (with cereals, root crops and rape) and 20% of grasslands, woodlands, built-up areas and small water bodies. Of two bigger plots (each of 800 ha) one was localised in Poland (P) and one in Germany (G). Four smaller plots (each of 185 ha) were localised in Poland (A, B, C and D).

METHODS

Bird species number was determined on all six plots by point counts method. Birds were counted during 10 min/point within the same radius for all species. Following observations were interpreted as a breeding pair: males with or without territorial behaviour as well as females if males were not observed. The birds flying over were not taken into account. Two variants of the method were used:

1) To define a general pattern of the relation between species number and sample size, on two bigger plots (P and G) birds were counted around 52 points up to 150 m from point. The points were regularly distributed (each 350–400 m). Counting was carried out in one time in the breeding season (12–28 May 1994).

2) The influence of farmland structure on the relation between sample size and the number of species was studied on plots A, B, C and D. The birds were counted around 30 points/plot up to 100 m from point in two terms in breeding season: 18–30 April, and 25 May–5 June 1995. Plots were localised in following types of farmland:

a) "homogeneous" — crop fields, with ca 3% of afforested areas (plot A),

b) "with shelterbelts" — crop fields, with 8% of afforested areas shaped mainly as shelterbelts (plot B),

c) "with small woods" — crop fields, with 21% of forest islands (plot C),

d) "with large woods" — crop fields, with 41% of big forest complexes (plot D).

The relation between the number of points and the number of species was determined by the analysis of the increment of total number of recorded species followed by the increment of the number of points. Summing up the points was performed 20 times with randomised rotation. Significance of that relation was testified using the equation: $S = cA^z$ (see Introduction).

Significance of the relation between the landscape structure and the parameters of equation was checked by Spearman's rank correlation analysis. Landscape structure was quantified by following variables: a) % of crop fields, b) % of grasslands, c) % of woodlands, d) % of built-up areas, e) % of water bodies, f) Shannon-Wiener's diversity index

$$H' = -\sum p_i \ln p_i$$

(where p_i — the proportion of habitats listed above), g) the density of woodlands edges and h) the density of all boundaries between distinguished habitats.

RESULTS

Number of counting points and the number of species

The number of species recorded on the plots P and G increased with number of points (Fig. 1). This increment was non-linear: from 0 to 10 points the species number increased correspondingly by 18 and 22, from 11 to 20 points — by 6 and 10, from 21 to 30 points — by 5 and 5, from 31 to 40 points — by 2 and 2, from 41 to 50 points — by 1 and 2. So, it seems that further enlargement of sample size would not allow to record significant number of new species — probably lower then 1 species per next 10 points.

Observed numbers of species are well fitted to the model $S = cA^z$, which explains 96% (G) and 97% (P) of observed variability. However, in both landscapes the model overestimated the expected values for small (< 10) and big (> 40) numbers of points, while for middle numbers of points expected values were underestimated (Fig. 1).

The influence of landscape pattern

For all studied types of the farmland the general pattern of the relation between species number and number of points was non-linear, well fitted to ac-

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cepted model $S = cA^z$, which explained 95.5–99.3% of observed variability. Similar to former analysis based on longer series of 52 points, accepted model overestimated the predicted number of species for small and big numbers of points, but underestimated predicted values for middle numbers of points (Fig. 2).

In homogeneous farmland (almost without non-farmed elements) the relation between the number of points and the number of species was close to linear. It means that this type of farmland requires much bigger number of points to collect representative data than farmlands characterised by the presence of woods, shelterbelts etc. It seems that fifty points is minimal sample size which can be used for comparison of species number between plots in farmland or between years.

Pattern of the relation between the coefficient of variability of species number and number of points was different in the studied farmlands (Fig. 3). For example, the coefficient amounted to 20% for 5 points in farmland "with small woods" or "with shelterbelts", while up to for 20 points in "homogeneous" farmland.

Among the parameters of model (i.e. *c* and *z*) *c* was much more correlated with the landscape structure (Table 1), e.g. especially with the percentage of crop fields, percentage of woodlands and H' (plot

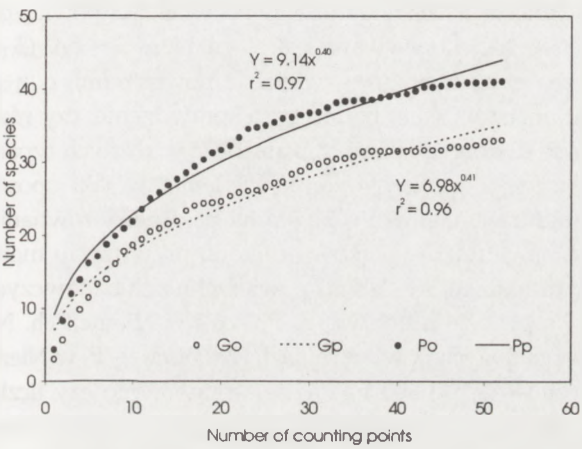

Fig. 1. Relation between sample size (number of points) and the number of species on plots P and G. Po, Go — values observed; Pp, Gp — predicted.

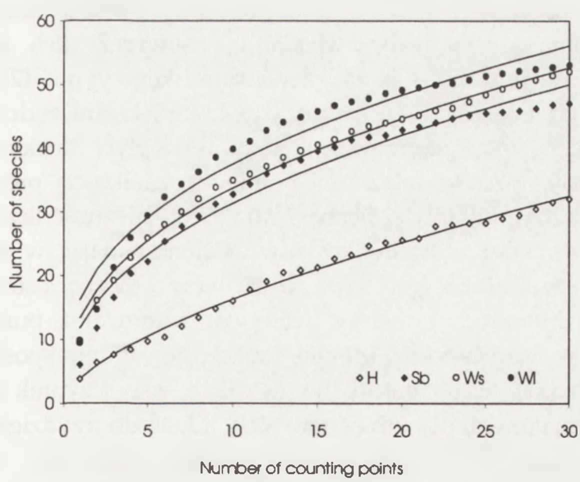

Fig. 2. Relation between the number of species and sample size in different agricultural landscapes. Dots — values observed, lines — predicted. H — homogenous farmland ($y = 3.79x^{0.61}$, $r^2 = 0.99$), Sb — with shelterbelts ($y = 11.72x^{0.41}$, $r^2 = 0.97$), Ws - with small woods ($y = 13.26x^{0.41}$, $r^2 = 0.99$), Wl — with large woods ($y = 16.13x^{0.37}$, $r^2 = 0.95$).

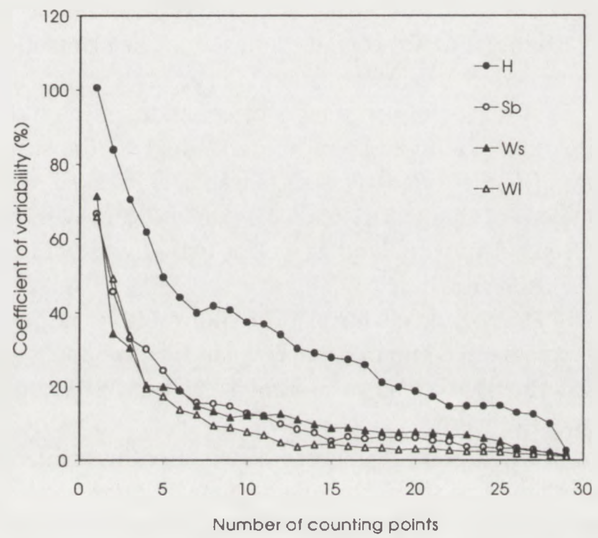

Fig. 3. Relation between coefficient of variability of species numbers and sample size in different agricultural landscapes. H — homogenous farmland, Sb — with shelterbelts, Ws — with small woods, Wl — with large woods.

Table 1. Coefficients of Spearman's rank correlation between the parameters of the equation $S = cA^z$ and the habitat variables. * $p < 0.05$.

Parameters of landscape structure	*c*	*z*
Crop fields (%)	-0.9*	0.7
Woodland (%)	0.9*	-1.0*
Grassland (%)	0.2	0.0
Built-up area (%)	-0.2	0.6
Shannon-Wiener's diversity index H'	0.9*	-0.7
Woodland edges per area unit	0.1	0.0
All habitat edges per area unit	0.1	0.0

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"Knetzgau" was excluded from the analysis because of lack of data on landscape structure). Parameter z seems to be much more weakly linked to the structure of landscape. It confirms Rosenzweig's (1996) opinion that the value of parameter z is related mainly to the scale of analysis of the species-area curve, but not to the habitat structure.

CONCLUSIONS

1) In the material studied the equation $S = cA^z$ well described the relation between the number of bird species breeding in farmland and number of points. In six examples analysed the coefficient of determination amounted to 0.95–0.99.

2) Among the parameters of equation, *c* was more differentiated, and also more dependent on the structure of landscape. It was significantly correlated with the percentage of crop fields (negatively), and with the percentage of woodland as well as with diversity index H' (positively).

3) Homogeneous farmland requires higher number of points (if compared to farmland with woods or shelterbelts) to achieve assumed error in bird abundance estimation.

4) When point counts method is used in farmland, comparison of species richness between different plots, or between years, should be based on at least 50 points.

REFERENCES

Górski W. 1988. [Birds breeding in the farmland of the Damnica Plateau (NW Poland)]. Acta orn. 24: 29–61.

Jermaczek D., Tryjanowski P. 1990. [Breeding bird communities in the farmland of Ziemia Lubuska and Western Wielkopolska (western Poland) with the consideration of arable fields]. Lubuski Przegląd Przyrodniczy 1: 3–26.

Kot H. 1988. The effect of suburban landscape structure on communities of breeding birds. Pol. ecol. Stud. 14: 235–261.

Kujawa K. 1994. Influence of land-use change within agricultural landscapes on the abundance and diversity of breeding bird communities. In: Ryszkowski L., Bałazy S. (eds.). Functional appraisal of agricultural landscapes in Europe. RCAFE, Poznań, pp. 183–196.

Rosenzweig M. L. 1996. Species diversity in space and time. Cambridge Univ. Press, New York.

Tomiałojć L. 1997. [On the necessity to develop an integrated scheme for bird monitoring in Poland]. Notatki Ornitologiczne 38: 239–254.

Tryjanowski P. 1999. Effect of habitat diversity on breeding birds: comparison of farmland bird community in the region of Wielkopolska (W Poland) with relevant data from other European studies. Pol. J. Ecol. 47: 153–174.

STRESZCZENIE

[Ocena liczby gatunków na obszarach rolniczych metodą punktową: znaczenie struktury krajobrazu i liczby punktów]

Zależność liczby gatunków od wielkości powierzchni najczęściej opisywana jest równaniem $S = cA^z$ (S — liczba gatunków, A — wielkość powierzchni, c, z — parametry). Celem badań było sprawdzenie, czy równanie to dobrze opisuje tę zależność w różnych typach krajobrazu rolniczego oraz ustalenie, w jaki sposób struktura krajobrazu wpływa na parametry równania. Liczbę gatunków ptaków oceniono przy użyciu metody punktowej na sześciu powierzchniach badawczych w krajobrazie rolniczym w Polsce i w Niemczech. Na dwóch dużych powierzchniach (w Polsce — P, w Niemczech — G, po 800 ha każda) sprawdzono czy liczba gatunków w stosunkowo dużej skali przestrzennej zależna jest od wielkości próby zgodnie z powyższym równaniem. Na czterech mniejszych (po 185 ha) powierzchniach w Polsce: A — w krajobrazie rolniczym „uproszczonym" (3% zadrzewień), B — w krajobrazie rolniczym „z zadrzewieniami pasowymi" (8% zadrzewień), C — „z zadrzewieniami kępowymi" (21% zadrzewień), D — „z dużymi kompleksami zadrzewień" (41% zadrzewień), oceniono wpływ struktury krajobrazu na zależności pomiędzy wielkością próby (liczbą punktów) i liczbą gatunków. Zależność liczby gatunków od liczby punktów ustalono badając, w jaki sposób liczba gatunków rośnie wraz z liczbą losowo wybieranych punktów. Kolejność sumowania punktów losowano 20-krotnie, obliczając w ten sposób średnią liczbę gatunków (a także współczynnik jej zmienności) dla jednego, dwóch, itd. aż do trzydziestu punktów. Istotność zależności liczby gatunków od liczby punktów testowano korzystając z przytoczonego wyżej równania. Liczba gatunków stwierdzonych na powierzchniach P i G wzrastała wraz z liczbą punktów nieliniowo (Fig. 1), stosunkowo zgodnie z rozważanym

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modelem — liczba punktów objaśniała na tych powierzchniach odpowiednio 96% i 97% zmienności w liczbie gatunków. Model ten dobrze opisywał badaną zależność również na czterech mniejszych powierzchniach o zróżnicowanej strukturze krajobrazu (Fig. 2). Według tego modelu od liczby punktów zależało 95.5 do 99.3% zmienności w liczbie gatunków, jednak parametry równania były silnie zróżnicowane — c wynosiło od 3.79 do 16.13, z — od 0.37 do 0.63 (Fig. 2). W krajobrazie „uproszczonym" (A) zależność liczby gatunków od liczby punktów była prawie prostoliniowa, a w krajobrazie „z dużymi kompleksami zadrzewień" (D) najbardziej krzywoliniowa. Zależność pomiędzy współczynnikiem zmienności liczby gatunków a liczbą punktów również kształtowała się różnie w różnych typach krajobrazu. W krajobrazie uproszczonym współczynnik ten, dla danej liczby punktów, miał znacznie wyższe wartości, niż w pozostałych typach krajobrazu i osiągał wartości zbliżone do notowanych dla innych, bardziej urozmaiconych krajobrazów rolniczych dopiero przy liczbie punktów bliskiej 30. Wśród parametrów równania parametr *c* był bardziej zróżnicowany i silniej skorelowany ze zmiennymi opisującymi strukturę krajobrazu — udziałem pól uprawnych, lasów oraz wskaźnikiem różnorodności H' (Tab. 1). Potwierdza to jedno ze spostrzeżeń Rosenzweiga (1996), że parametr z jest stosunkowo mało zależny od typu środowiska, a jego wartości związane są raczej ze skalą prowadzenia badania. Z przeprowadzonych analiz wynika, że, aby zniwelować wpływ różnic w strukturze krajobrazu rolniczego na uzyskane wyniki, porównania terenów pod względem liczby gatunków ptaków powinny być prowadzone na podstawie co najmniej 50 punktów.

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