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Монография содержит информацию о самых современных методологиях и результатах в ландшафтных исследованиях. Она может быть использована в качестве руководства для исследователей, преподавателей, студентов и всех, кого интересует тема ландшафтной науки и смежных дисциплин. Монография является особо ценной информационной базой для лиц, принимающих решения на различных уровнях, от местных до международных органов по принятию решений. Приведенная в монографии информация представляет собой современный уровень ландшафтной науки в очень краткой форме.

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Main editors: Lothar Mueller (Leibniz Centre for Agricultural Landscape Research, Muencheberg, Germany) and Viktor G. Sychev (All-Russian Research Institute of Agrochemistry named after D.N. Pryanishnikov, Moscow, Russia)

This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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Chapter III/28: CHARACTERISING THE ABUNDANCE DYNAMICS OF FARMLAND BIRDS BY THE MOVING WINDOW METHOD

Глава III/28: Характеристика динамики численности птиц сельскохозяйственных земель методом скользящего окна

Jörg Hoffmann*1; Udo Wittchen1; Ulrich Stachow[2]
DOI 10.25680/9194.2018.60.98.221
*Email: Joerg.hoffmann@julius-kuehn.de
1.Federal Reseach Centre for Cultivated Plants; Institute for Strategies and Technology Assessment, Stahnsdorfer Damm 81, D-14532 Kleinmachnow, Germany
2.Leibniz Centre for Agricultural Landscape Research (ZALF), Eberswalder Str. 84, 15374 Muencheberg, Germany

ABSTRACT. Measurements of bird abundance are a valuable basis for many ecological assessments. In most cases the abundances are expressed by the counts of bird individuals exhibiting territorial behaviour. Compared to the usual individual values of abundances, we propose a novel method which characterizes the dynamics of abundances during the breeding season. This methodological development is based on field surveys by "territory mapping" in agricultural landscapes. The abundance curves for the breeding season show the „Moving Window Abundance", derived at by three algorithms, Patchy-, Adjacent- and Overlapping Moving Window. At the example of the Skylark (*Alauda arvensis*) the results indicate the dynamics of bird abundance within landscape compartments and the landscape as a whole. The abundance curves for different crop species, for example wheat and maize, are strikingly different. The novel method can be integrated into monitoring programs and would make abundance values more meaningful as bioindicators.

Резюме. Показатель численности птиц является важной основой многих экологических оценок. В большинстве случаев такой показатель определяется через подсчеты отдельных индивидуумов, обитающих на территории. Для сравнения с обычными величинами численности индивидуумов в настоящей работе предлагается новый метод, который характеризует динамику численности в период размножения. Данное методологическое развитие опирается на полевые исследования с использованием «картографирования территорий» в сельскохозяйственных ландшафтах. Кривые численности для сезона размножения построены методом «Moving Window Abundance», использующим три алгоритма: «Patchy-», «Adjacent-» и «Overlapping Moving Window». На примере жаворонка полевого (*Alauda arvensis*) показана динамика численности птиц для отдельных участков ландшафта, а также для ландшафта в целом. Кривые численности, которые соответствуют ареалам разных сельскохозяйственных культур (например, пшеницы и кукурузы), имеют существенные различия. Новый метод может быть интегрирован в программу мониторинга; при этом показатель численности птиц приобретает ещё большее значение в качестве биоиндикатора.

KEYWORDS: Farmland birds, Skylark, Moving Window Abundance, Breeding season, agricultural landscape, field crops.
Ключевые слова: птицы сельскохозяйственных угодий, жаворонок, относительная численность, определенная методом скользящего окна, сезон размножения, сельскохозяйственный ландшафт, полевые культуры.

INTRODUCTION

Bird abundance data serve as an important base for the assessments of various biological characteristics, e.g. bird populations, regional and local situations, or as indication for biodiversity in habitats and landscapes. In seasonal regions, such as in Europe and Asia, most farmland bird species occupy breeding territories in the spring for the reproduction. These breeding season lies usually in Middle Europe between March and July. Depending on the type of species, one to three breeding cycles can be completed during this time range /1/. Normally, one to three observations of individuals or pairs with territorial behaviour are considered to be sufficient for assigning a territory (marked on the field map as territory point or small territory area) and in summary of all territories the abundance – the number of territories in a considered landscape section – for the breeding season /2, 3/. This method utilises the unit "territories per 10 or 100 ha" as one numerical abundance value /e.g. 1/. However, the method bears numerous uncertainties in subjective decisions on the declaration of the territories /2/ and finally in the calculation of the abundances. These decisions include the questions:

- whether one or two or even more observations of birds with territorial behaviour on a certain spot are necessary to qualify as proof of an existing breeding territory,
- what spatial distance (m) of consecutive observations of the occurrence of bird individuals with territorial behaviour can be tolerated to assign these to one territory,
- if a territory was occupied only for a short period of time and then deserted, consequently being not identified as territory although a breeding had begun or had not been detected,
- whether the bird individuals switched to another habitat within the landscape during the breeding season, so that the summation of such individual values results in too high abundance values.

After spring migration, bird species arrive at landscapes at different dates, and also the length of the breeding season differs between species. Depending on weather conditions, land use etc. this can also vary within a species. Moreover, the territorial behaviour, which is identifiable by the field surveys, may also vary during the breeding period, depending on the species and partly also on the region. All these possible sources of variation call for objective, unequivocal and reproducible methods to characterize the bird abundances which respect temporal dynamics.

AIMS OF THE PAPER

The aim is to develop a method which describes the abundances of bird with territorial behaviour (in a border sense breeding birds) within a landscape or parts of a landscape exactly during the breeding season by a calculation method. That means (the dynamic if applicable) abundance should be described by a mathematical function which respects all of the observed bird individuals and pairs with territorial behaviour over time. The data of the individuals and pairs with territorial behaviour are to be collected through field survey within defined investigation areas within the agricultural landscape. We chose the Skylark (*Alauda arvense*) as a model species for the development of the method, because it is a typical farmland bird species and bio-indicator for central European agricultural landscapes.

METHODS

The methodological development is based on data of the territory mapping of the birds /2, 4, 5, 8/ of 29 plots, each with a size of 1 km², within a German agricultural landscape (Fig. 1), studied in the year 2010 /6/. The total arable land was 2669 ha, structured in 136 single arable field’s /4/. The individual’s resp. pairs exhibiting territorial behaviour were mapped at eight dates, each within a time window of two weeks, beginning in the middle of March, and ending in the middle of July, hence each field was visited twice a month. Because the dates within the time windows were chosen almost randomly, data of individuals or pairs with territorial behaviour are available for almost every single day /4/.

The calculations of the bird abundances were done on the basis of all data (a total of 5661 observations of Skylarks with territorial behaviour) collected during the breeding season (March 16th to July 18th). Using the moving window approach, daily abundance values were calculated (in this method no observation data are ignored when calculation the abundance) with varying time window sizes: 1 day, 5 and 10 days, and half a month. Consequently, each value for a single day is calculated by all the values within the respective time window, i.e. the number of observed individuals or pairs with territorial behaviour per unit area. Because the Skylarks occur only on arable land, all data refer to these areas (see above). These values form the basis for the abundance functions for the breeding season, which we call Moving Window Abundance (MWA), see Fig. 2. Three calculation methods were distinguished and tested, Patchy Moving Window (PMWA), Adjacent Moving Window (AMWA) and Overlapping Moving Window (OMWA).
PMWA uses the exact dates on which observations were carried out. This may lead to some “zero abundance” values for single arable fields, if no birds with territorial behaviour were observed within that area. PMWA covers the whole breeding season and was executed in two ways: PMWA1 separately for the observations on each individual field on a day and PMWA2 for the sum of all observations on all fields made on a day. AMWA uses abundance values for consecutive time windows for 5 and 10 days and half month periods without overlap, whereas OMWA does the same as AMWA but with a shift of the window (5 days, 10 days, half a month) by one day for each value, resulting in an overlap of one day for two adjacent windows. The numbers of time windows for which abundance values were calculated by the algorithms differed accordingly: 1088 and 101 (PMWA1 and PMWA2); 25, 13 and 8 (AMWA1, AMWA2 and AMWA3); 121, 116 and 111 (OMWA1, OMWA2 and OMWA3), and formed different bases for

MWA calculations /7/. The three calculation methods were conducted by the NLIN procedure with the statistical software package 'SAS'™ for the entire landscape and separately for the field crops of winter oilseed rape and maize.

Figure 1 – German agricultural landscape – subarea of one of the investigation areas; left side – field with oilseed rape, middle – diverse structured hedge, right – field with maize to the beginning of growth. Photo: Jörg Hoffmann

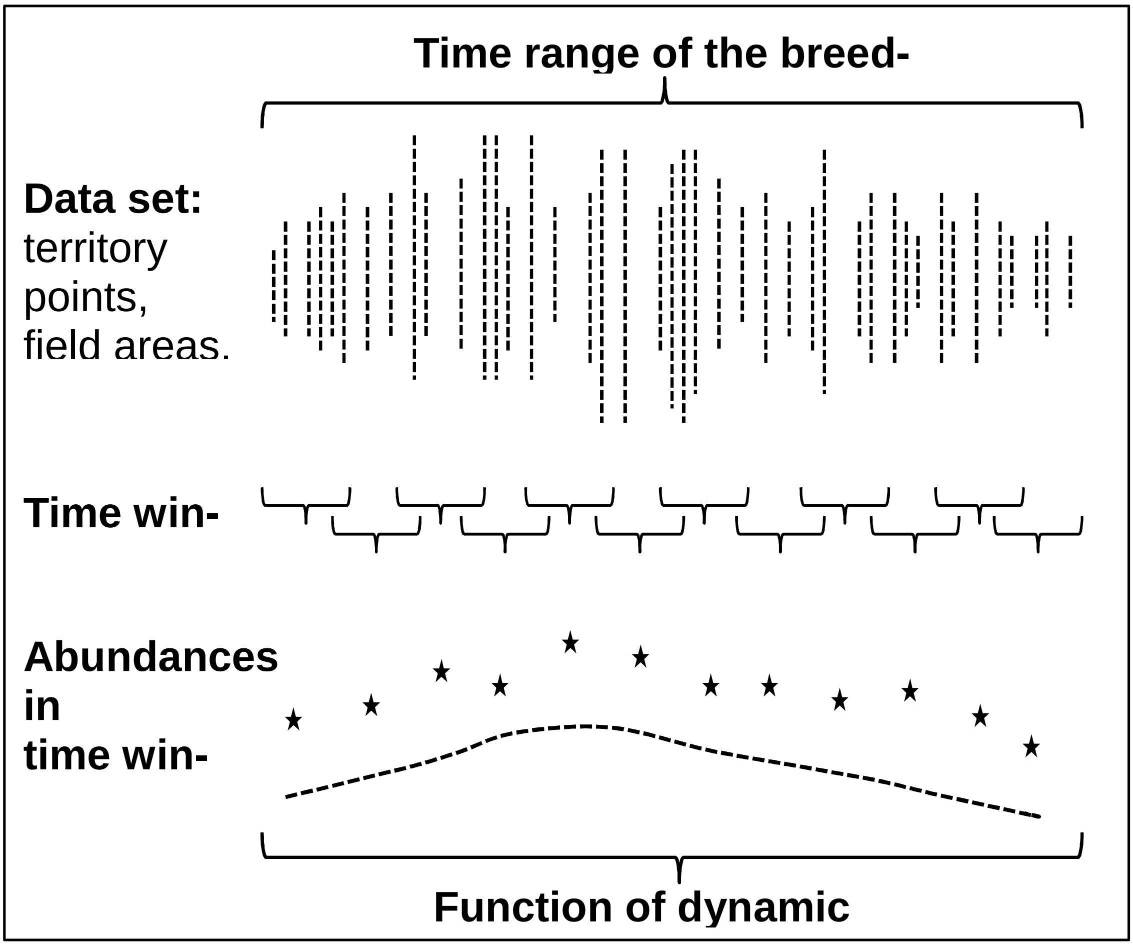

Figure 2 – Scheme of the Moving Window Abundance (MWA): entire time range of the breeding season, data sets of abundance values throughout the breeding season, selected time windows, calculated abundance values within the time windows and functions of the dynamic abundance /7/.

The MWA functions to describe the abundances by applying PMWA, AMWA and OMWA are summarized in Table 1. PMWA1 exhibits large variance and is not significant, all other functions are significant. The abundance of Skylarks during the breeding season (four months) across the agricultural landscape, characterized by the 29 plots, exhibits temporal dynamics in all calculation procedures, as shown by statistical parameters (significance, standard deviation, variability, minimum, median, maximum). Depending on the algorithm applied the abundance maximum is found during the second half of April or beginning of May.

RESULTS

We used OMWA for further statistical tests and MWA calculations because of smaller variances and larger number of daily values compared to PMWA. In this way significant differences between crop species became obvious, specifying the overall abundance of the whole landscape. As an example shown in Figure 2, a comparison between oilseed rape, grown on 689ha, and maize (649 ha) reveals that in oilseed rape fields the abundance maximum of Skylark is reached 44 days earlier than in maize, i.e. middle of April (the 107th day) vs. maize in the end of May (151th day). Similarly, the values of the mathematical functions of MWA between the crop species partly indicate large differences /7/.

Table 1: Functions of the Skylark abundances (parameters and statistics) for the Moving Window Abundance (MWA) methods (A – abundance, ITB – individuals or pairs with territorial behaviour).

Methods	MWA functions: $y = ax^2 + bx + c$			p	Range of A (ITB/10 ha)		A maximum (time phase)
	a	b	C		from	to	
PMWA1	-0.00023732	0.06129	-0.68276	0.0230	2.08	3.27	129. day
PMWA2	-0.00022488	0.05453	-0.39370	0.0005	1.57	2.91	121. day
AMWA1	-0.00550	0.26122	-0.16610	< 0.0001	1.48	3.01	5. April-pentad
AMWA2	-0.02102	0.51033	-0.20053	0.0004	1.60	2.90	3. April-decade
AMWA3	-0.05480	0.90395	-0.81050	0.0036	1.52	2.92	2. April-half
OMWA1	-0.00022435	0.05223	-0.10643	< 0.0001	1.37	2.93	116. day
OMWA2	-0.00021410	0.04821	+0.23351	< 0.0001	1.31	2.95	113. day
OMWA3	-0.00021607	0.04853	+0.21863	< 0.0001	1.50	2.94	112. day

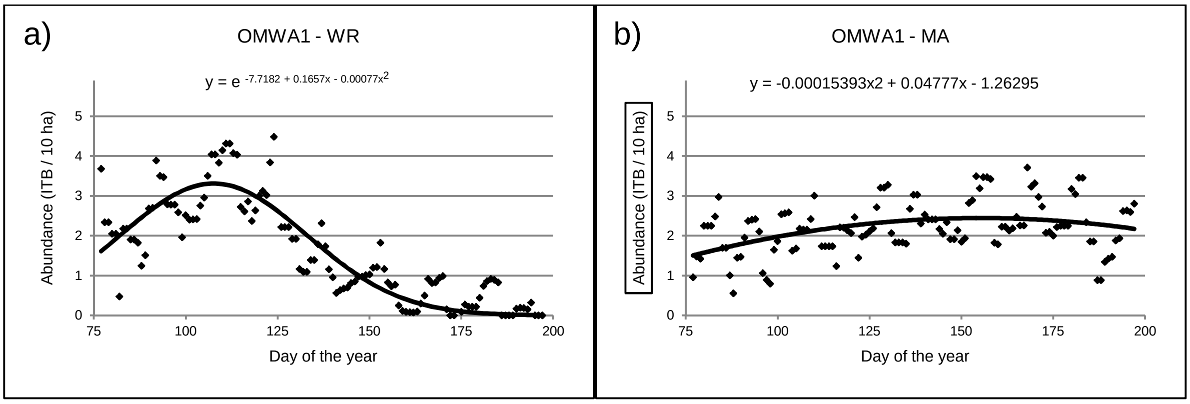

Figure 2 - Abundance (individuals or pairs with territorial behaviour (ITB) per 10 ha) and progression of the Moving Window Abundance (MWA) of the Skylark according to the OMWA1 in a) WR – winter oilseed rape and b) MA – maize. /9/.

APPLICATION

The application of MWA to characterize bird abundances sets important methodological quality standards in respect to objectivity and reproducibility which might be especially useful for bird monitoring programs in landscapes /5, 6/ by which many data on bird species with territorial behavior are generated. All data are stored in data bases, in the calculation algorithms are integrated and the mathematical functions can be tested statistically. This makes the results unequivocal, traceable and transparent. The new Moving

Window Abundance Method has potential for applications and adoptions to bird monitoring in various landscapes, e.g. in Central and Western Europe, Russia and Central Asia.

CONCLUSIONS

1. The length of the breeding season and changes in habitat conditions pose challenges to the characterisation of abundances of breeding birds in agricultural landscapes.
2. Single values does not sufficiently describe the processes that occur during this period if the abundance values vary within the breeding season. Hence, in such cases, habitat evaluations are restricted.
3. Because single abundance values on a landscape scale (in this case, agricultural landscapes) and habitat scales (in this case, crop fields) exhibit large variations which was shown with the MWA method, their use as a basis for general statements is statistically valid only when there is a sufficient sample size and temporal dynamics are considered.
4. These requirements pose challenges for future field surveys and data analyses in research in particular but also for on-going monitoring programs. Monitoring programs may profit by better accuracy.
5. Statistically valid parameters of the abundance equations can be inferred, including maximum, mean, median and integral. This parameters improve analyzes of cause and effect relationships.

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