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ISSN 0065-1710

Cover Design
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nakład 550 egz. + 25

Acta zoologica cracoviensia, **44**(2): 85-92, Kraków, 29 June, 2001

Dealing with uneven recording effort in regional atlas projects on the distribution of amphibians and reptiles

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Received: 3 Oct., 2000

Accepted for publication: 7 May, 2001

ZIELIŃSKI P. 2001. Dealing with uneven recording effort in regional atlas projects on the distribution of amphibians and reptiles. *Acta zoologica cracoviensia*, **44**(2): 85-92.

Abstract. Regional atlas studies on the distribution of animals or plants are carried out on the basis of the presence or absence of a species in grid squares, and usually volunteer recorders supply the greatest number of data. As a result, in most atlas schemes the squares differ greatly with respect to the degree of survey effort, making calculations of a species' frequency of occurrence in space difficult. Here the author proposes a method of summarising results of regional atlas projects using the number of species recorded in each square as a measure of the recorder effort. This makes possible the calculation of an index of a species' frequency of occurrence in space (reflecting how common is the species) on the basis of the number of squares and the number of species found in squares studied. The above procedure is illustrated using data on the distribution of amphibians and reptiles in central Poland.

Key-words: faunistics, atlas projects, amphibians, reptiles.

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I. INTRODUCTION

Knowledge of the distribution of different groups of animal or plants is essential in estimating the abundance of a given species, in evaluating hotspots of species richness, and in determining regional priorities for conservational purposes (HAILA & MARGULES 1996, GASC et al. 1997, STRAYER 1999). Studies on the distribution of species are usually carried out on the basis of their presence or absence in national or regional atlas grid squares (PLANT 1983, HEATH et al. 1984, BUCKLEY 1989, KUIPER et al. 1989, MAJERUS et al. 1990, TERHIVUO 1993, ARNOLD 1995, GASC et al. 1997, CLEMONS 1998, HARRISON & BURGER 1998).

Records are biased in many ways. They are gathered by a great number of people (recorders) usually differing in experience and efficiency (NILSON & ANDRÉ 1988, ARNOLD 1995, CLEMONS 1998, HARRISON & BURGER 1998, HENKE 1998), trying to find as many species of a given group as possible. A serious deficiency of the atlas data is that the grid squares differ greatly with respect to the degree of survey effort. Some squares are very well-studied – there we can expect the maximum or close to the maximum number of species recorded. Some are merely touched upon with usually one or a few species found. In an ideal situation squares should not differ with respect to recorder effort and coverage. This scheme, however is rarely achieved in practice.

In a simple distribution atlas we are mainly interested in species composition and how common is each of the species recorded. One method of summarising the results is to calculate the frequency of a species' occurrence in space on the basis of the number of squares with the species recorded (irrespective of its abundance) divided by the total number of squares studied i.e. squares with at least one reliable record. Squares not studied at all are of course not included in the calculations. Within limits, frequency of occurrence might also give us a crude index of relative abundance.

We may expect that a species recorded in e.g. 80% of squares is common throughout the area studied, while the distribution of a species recorded in only 20% of squares is restricted to certain areas only. The danger however is that if all the squares are not well-studied such calculations might be serious underestimates. The aim of this paper is to present a method of summarizing regional atlas projects by calculating an index of a species' frequency of occurrence in space based on the number of squares and the number of species found in squares studied.

A c k n o w l e d g e m e n t s. The author wishes to thank Stuart BUTCHART (Department of Zoology, Cambridge University) for helpful comments on the manuscript.

II. METHODS

Calculating an index of a species' frequency of occurrence in space

Imagine a uniform study area comprising 100 atlas squares. We examine the general distribution of amphibians in that area. The smooth newt *T. vulgaris* was found in 20 squares. In each of these 20 squares altogether ten species (including the common toad *B. bufo*) of amphibians were found. From the other 80 much less intensively examined squares we only have records of the common toad presence and we have no data on the confirmed absence of the smooth newt there. We do not know if there are other species of amphibians or not but we know that only one species was recorded and thus the recording effort was relatively low. If we calculate the simple measure of the frequency of occurrence in space of the smooth newt we get 20% only (20/(20+80)). This is far less than we expected it to be after careful examination of some of the squares. However, if we consider the limited value of information we have about less intensively examined squares we can obtain more realistic data. We can calculate the frequency based not on the number of squares only, but on the number of squares and the number of species found in each square. The formula is:

$$f = \frac{\sum_{i=1}^{n} k_i}{\sum_{i=1}^{N} s_i} \qquad (1)$$

where

f – index of a species' frequency of occurrence in space

n – number of atlas squares with the given species recorded

k_i – number of species recorded in the i-th square with the given species recorded

N – total number of squares examined

s_i – number of species recorded in the i-th square

Applying this procedure we rank the squares according to the amount of knowledge (measured by the number of species recorded) that we have about the species composition in each particular square. Returning to our example we obtain

$f = 200/(200 + 80) = 71\%$

which is much closer to what our field experience told us about the distribution of the smooth newt in our study area. We obtained a higher value because the information from the squares with the common toad only were given a relatively very low rank, according to the very low level of knowledge of the species composition in those fields, based on the number of species found. The *f* value for the common toad, which was found in all the squares studied, is:

$f = (20*10 + 80*1)/280 = 100\%$

The above calculations are reasonable under the following assumptions:

– species richness and composition is uniform over the study area;

– recorders' effort (no matter whether high or low) is randomly distributed over the study area;

The first assumption means that the index is suitable for rather homogeneous areas at the local or regional level but unsuitable for describing one large area comprising different regions with different faunas, i.e. lowlands and mountains. However, one can calculate and compare the *f* values for the two regions separately. The second assumption says that recorders should not show preferences only for certain areas.

Materials

To illustrate the above considerations the author used data concerning the distribution of amphibians and reptiles in central Poland, Łódź province (ZIELIŃSKI et al. in press). The study area – approx. 20,000 km^2 – covered central Poland from 51°00'N to 52°15'N and from 18°20'E to 20°20'E (Fig. 1). The area was divided into 180 fields based on the geographic grid. Each grid field was 5' high and 10' wide, i.e. about 110 km^2. All the data were gathered between 1980 and 1997, most of them, however, between 1994 and 1997 (ZIELIŃSKI et al. in press).

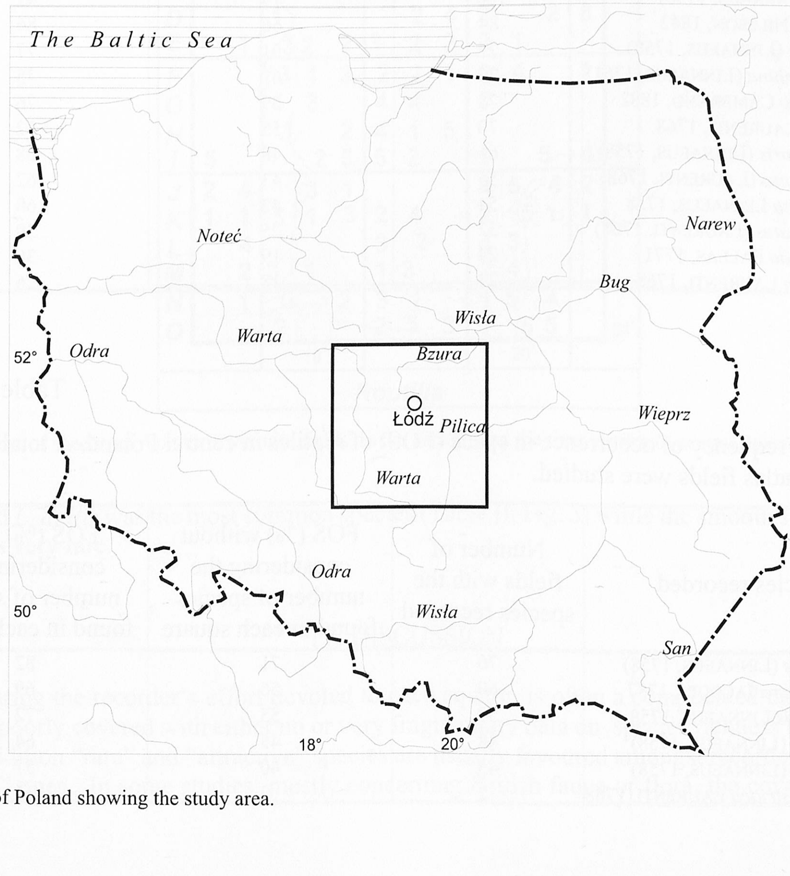

Fig. 1. Map of Poland showing the study area.

III. RESULTS

A total of 1602 records of amphibians and 494 records of reptiles were supplied by 74 recorders, covering 71% (127) and 59% (107) of the total number of fields respectively (ZIELIŃSKI et al. in press). Tables I and II provide approximation of a species' frequency of occurrence in space based on the frequency measure with and without considering the number of species found in each field. Data on the number of species of amphibians and reptiles found in each field are presented in Figs 2 and 3 respectively. The frequency index calculated according to formula (1) resulted in higher frequency values for all the species. Two amphibian species – the common frog *R. temporaria* and common toad *B. bufo* – exceed a 90% frequency threshold and appeared to be very common in the study area (Table I). None of the amphibian species appeared to be very rare and only the index of frequency of the natterjack *B. calamita* was lower than 30% (Table I, Fig 4). Among reptiles the

Table I

Frequency of occurrence in space (FOS) of amphibians in central Poland. A total of 127 atlas fields were studied.

Species recorded	Number of fields with the species recorded	FOS (%) without considering the number of species found in each square	FOS (%) after considering the number of species found in each square
Rana temporaria LINNAEUS, 1758	104	82	93
Bufo bufo (LINNAEUS, 1758)	100	79	91
Rana arvalis NILSSON, 1842	84	66	84
Hyla arborea (LINNAEUS, 1758)	77	61	77
Bombina bombina (LINNAEUS, 1761)	77	61	75
Rana lessonae CAMERANO, 1882	75	59	76
Bufo viridis LAURENTI, 1768	70	55	72
Triturus vulgaris (LINNAEUS, 1758)	61	48	68
Pelobates fuscus (LAURENTI, 1768)	55	43	62
Rana esculenta LINNAEUS, 1758	54	42	60
Triturus cristatus (LAURENTI, 1768)	32	25	39
Rana ridibunda PALLAS, 1771	24	19	30
Bufo calamita LAURENTI, 1768	23	18	26

Table II

Frequency of occurrence in space (FOS) of reptiles in central Poland. A total of 107 atlas fields were studied.

Species recorded	Number of fields with the species recorded	FOS (%) without considering the number of species found in each square	FOS (%) after considering the number of species found in each square
Lacerta agilis (LINNAEUS, 1758)	76	71	82
Lacerta vivipara JACQUIN, 1787	60	56	69
Anguis fragilis LINNAEUS, 1758	59	55	72
Natrix natrix (LINNAEUS, 1758)	48	45	64
Vipera berus (LINNAEUS, 1758)	43	40	57
Coronella austriaca LAURENTI, 1768	2	2	4

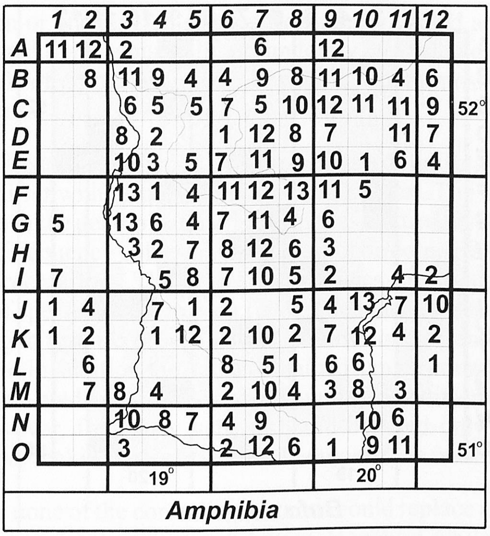

Fig. 2. Number of species of amphibians recorded in the atlas fields. In the background the river system of central Poland.

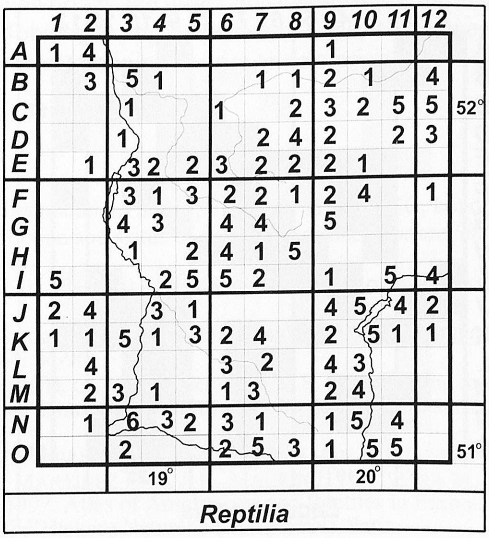

Fig. 3. Number of species of reptiles in the atlas fields. In the background the river system of central Poland.

sand lizard *L. agilis* was the most common species (Table II, Fig. 5) while the smooth snake *C. austriaca* was very rare.

IV. DISCUSSION

Measuring the recorder's effort devoted to each square is often a complicated task. Some regions are poorly covered with either no or very fragmentary data on species richness and distribution. In addition "rare" and "attractive" species are usually favoured amongst recorders more than "common" ones. In some studies, mostly concerning British fauna or flora, the coverage gained

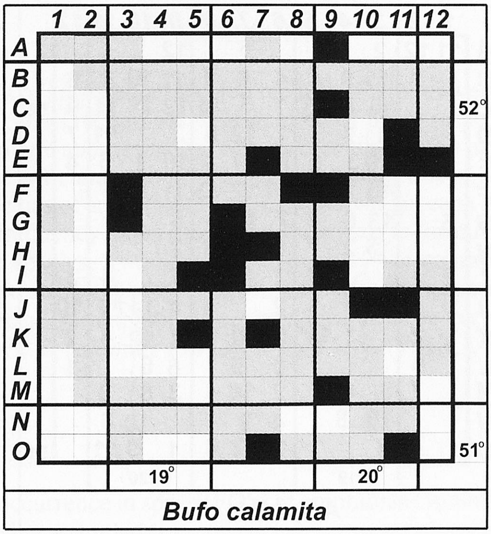

Fig. 4. Distribution of the natterjack *B.calamita* in central Poland. Explanation of field pattern: open – no data, black – species in question recorded, shaded – field visited, species in question not recorded

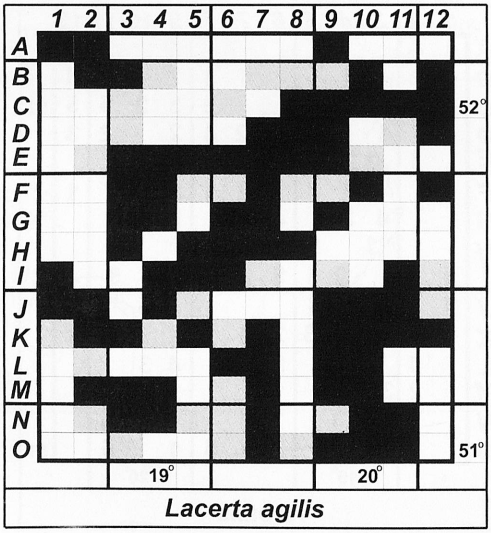

Fig. 5. Distribution of the sand lizard *L. agilis* in central Poland. For explanation see Fig. 4.

was 100% or close to 100% and subsequent surveys were gradually improved by carefully prepared schemes, including gathering data time regime and high coverage (TAYLOR 1948, TAYLOR 1963, ARNOLD 1995). Thus, some of the biases were avoided and far more accurate results were obtained (ARNOLD 1995). However, in some regions, variation in recorder effort and poor coverage resulted in biased data reflecting more strongly the recorder's preferences for certain attractive or more accessible areas rather than species distribution (FREITAG et al. 1998).

Another deficiency is that inputs from recorders usually contain no indication of the amount of time spent in the square. A possible solution to this bias is to use data only from thoroughly investigated squares (FOG 1988) and extrapolate them to less intensively recorded squares. However, this might mean wasting a large number of reliable though opportunistic data supplied by recorders, often concerning uncommon or endangered species from rarely visited areas. In addition, primary survey data, though gathered opportunistically or randomly, are often extremely valuable, reflecting the efforts of hundreds of enthusiastic people without whom most of the atlas studies could never have been carried out.

Calculating a species' frequency of occurrence on the basis of the total number of squares is simply wrong when squares differ with respect to the recorder's effort. The resulting values are always lower, because we include in the denominator all the squares studied, even those less intensively investigated. In addition the frequency values obtained cannot be compared with other regions differing with respect to recorder effort. The above deficiencies are avoided if we include in our calculations the number of species found in each field. The index of a species' frequency of occurrence calculated according to formula (1) enables us to draw conclusions concerning how common a species is in a study area. In addition the values obtained can be compared between different regions with similar faunas covered by the same size grid units, even differing with respect to recorder effort and coverage. However, frequency values should be used only when a large number of squares have been sampled, making calculations and comparisons reasonable.

It must be stressed that none of the correcting methods could replace a detailed data set resulting from standardised studies on animal or plant distribution. However, while acknowledging the shortcomings of the data, every effort should be undertaken to make full use of all the existing data. The conclusion of this paper is that, even in provisional summaries resulting from fragmentary data sets contributed by amateur fieldworkers and professional herpetologists, it is possible to calculate, using the approach described above, an approximation of a species' frequency of occurrence in space. This could greatly help us in determining species or area priorities for conservation purposes.

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