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The method of running-averages in the study of breeding parameters: an example of the Blackbirds (Turdus merula)

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The seasonal variation of breeding parameters is usually described by calculating the averages of parameters in non-overlapping intervals. This method has two disadvantages: (1) the improper choice of the interval-length makes it impossible to detect either the seasonality or the correlation between parameters in some cases, and (2) even if the interval-length is correct, the detection of seasonality depends on the starting point of the first interval. These problems are discussed in relation to our data collected in an urban Blackbird population during four successive breeding seasons from 1986 to 1989. The method of calculating running-averages is recommended which offsets the above mentioned disadvantages. However this method raises some new problems which are also discussed.

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1. Introduction

As in other open-nesters, Blackbirds (*Turdus merula*) usually lay two or three (or more) clutches during a breeding season. Consequently their breeding season lasts three to four months. This makes it possible to study the effect of changes in the environment on the breeding parameters during a season.

The seasonality of breeding parameters or their relationships are usually determined by sorting data into non-overlapping intervals and calculating their averages and the correlation between the different parameters. The interval-length depends on the amount of data, authors usually calculate monthly (Snow 1955, 1969, Saemann 1979), half-monthly (Snow 1958, Ribaut 1964), 10-day (Havlin 1963), weekly (Perez et al. 1979), or 5-day averages (Havlin 1963, Dyrcz 1969). If we have only few data and we use short intervals, the effect of the seasonality can be hidden by random fluctuations. On the other hand if we use too long intervals, the seasonality of parameters cannot be detected either. This is because in this case data from breeding attempts under quite different circumstances are drawn together. An extreme example is when the interval-length equals with the length of the whole breeding season.

Another, usually neglected problem is defining the starting-point of the first interval. The finer the arrangement of intervals (in the case of a large data-set shorter intervals can be used), the less important the problem is. However if the interval-length exceeds the 15-20% of the length of the breeding season, the improper marking of the starting point of the first interval may cause serious problems, and it can be a matter of chance whether the seasonality or the relationship between the parameters appear or not.

This paper uses the well-known method of calculating running averages to avoid or resolve these problems in the examination of seasonality of breeding parameters in an urban blackbird population.

2. Material and methods

Data were collected during a long-term study of the breeding of an urban blackbird population from 1986 to 1989. Our study area, the Vérmező is a 13 ha park in the middle of Budapest. It consists of large areas of lawn with a great variety of scattered bushes and trees. About 60-70 pairs of blackbirds breed in the area and lay about 150-200 clutches in a year. During the four years, 447 nests were examined from which 365 were considered complete. Only breeding data from these nests were involved in further analysis.

In theory running averages can be calculated in two ways. In the first method the daily averages are calculated first, then the running-averages of intervals from the first, second etc. days are calculated from these averages. In case of a small data-set the number of data per day may be very variable and perhaps there may be days without any data. Consequently it is better if we calculate the running averages from rough data. This method is in fact nothing else than the extension of calculating the averages of non-overlapping periods for each possible case according to the following process:

Let us choose a possible interval-length (L) and a starting-point (t). Let us calculate the average of the chosen parameter (a1) from data of nests started in the /t, t+L-1/ interval. In the following steps let us calculate the averages of parameters (a2, a3..ax) in the /t+1, t+1+L-1/, /t+2, t+2+L-1/ ..... /t+x, t+x+L-1/ intervals. Calculating the averages following each other we get the average of the interval /t+L, t+2L-1/ which is the first interval which does not overlap with our first interval (/t, t+L-1/). If the calculation of averages is carried out in non-overlapping intervals

$$/(t+m)+yL, (t+m)+(y+1)L-1/ \qquad (1)$$

- where *m* is the number of days with which the original starting-point (t) is modified and *y* is the serial number of non-overlapping intervals - then a series of averages of non-overlapping intervals can be calculated for each possible case of *y* at a constant value of *m*. By increasing *m* by one we get the next series of non-overlapping intervals etc. In this way we get the method used up to now with the difference that each possible series was calculated. If the interval-length is L, then L kinds of series of non-overlapping periods can be produced. If we do not specify the value of *y* and the averages are calculated in intervals

$$/t+x, t+x+L-1/ \qquad (2)$$

- then producing all kinds of possible averages, the series of series of non-overlapping intervals (1) are calculated. In this case each interval overlaps with L-1 other intervals. It is important to mention that in the case of the first and the last few intervals there are fewer data so their averages are not reliable.

3. The choice of interval-length

Example 1: the number of nests

The number of nests started in different periods of the breeding season is quite variable. During the field-work it seemed that many of nests began simultaneously at the beginning of the breeding season, later we

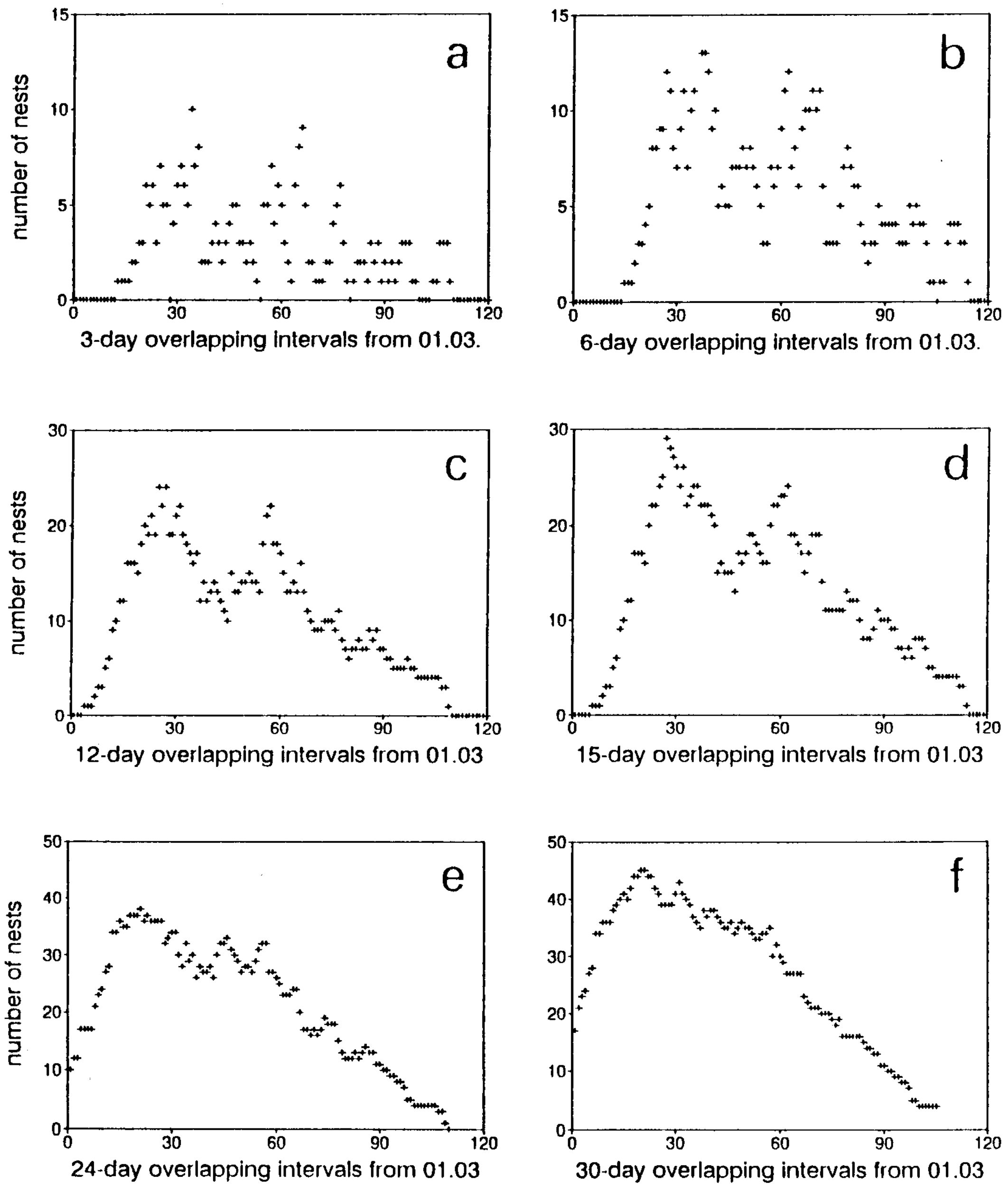

Fig. 1. The number of nests in 3-day (a), 12-day (c), 15-day (d), 24-day (e) and 30-day (f) overlapping intervals in 1988.

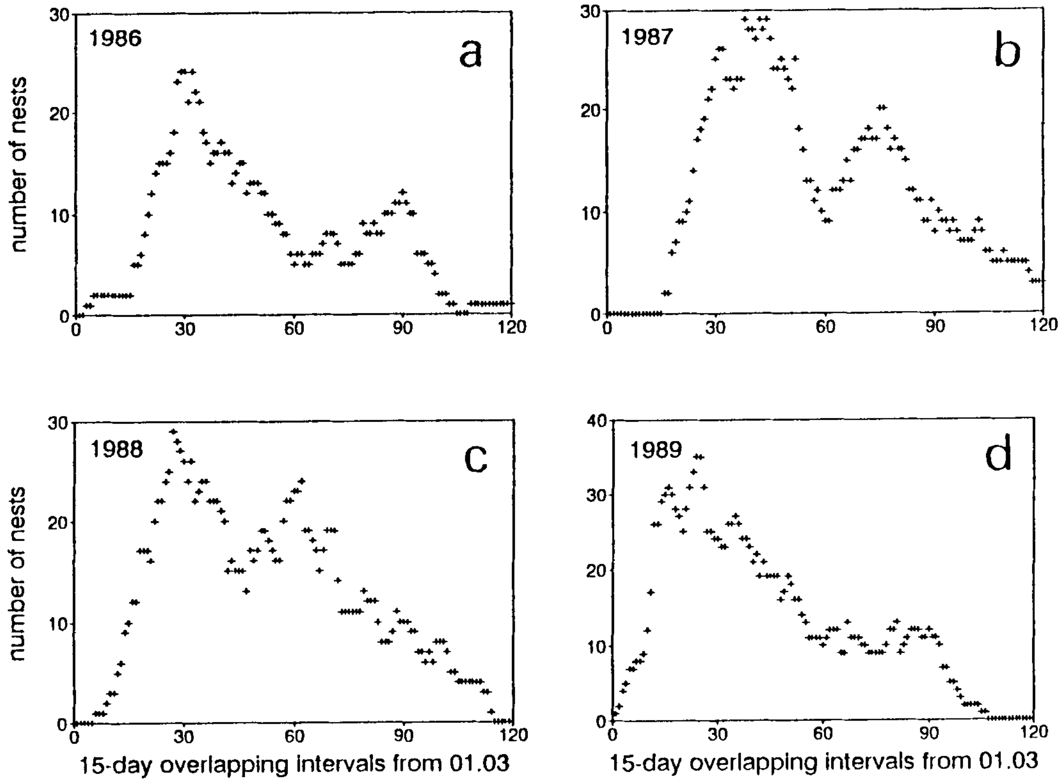

Fig. 2. The number of nests in 15-day overlapping intervals in 1986 (a), 1987 (b), 1988 (c) and 1989 (d).

found fewer nests, while in the middle of the season the number of nests increased again and finally decreased. The question is which interval-length can display this tendency. Let us demonstrate it on data from 1988.

First let us calculate the averages according to (2) in the case of different interval-lengths and let us represent them as a function of the serial number of overlapping periods (x) (Fig. 1) In the case of low values of L (Fig. 1a, b) the change in the number of nests does not appear, and in the case of large values of L (Fig. 1e, f) the change becomes smooth. In the case of medium values of L (Fig. 1c, d) both peaks in the number of nests are expressed. Breeding began on different dates in different years according to the weather (mainly the temperature). However at the appropriate interval-length the slopes of the first peaks seem to be similar in each year (Fig. 2) This characteristic feature of appearance of nests was used to synchronize the four years when their data were compiled.

Example 2: the seasonal pattern of breeding success

Many papers have described the seasonal pattern of breeding success (which is usually given as the proportion of successful nests in a given interval) in blackbirds.

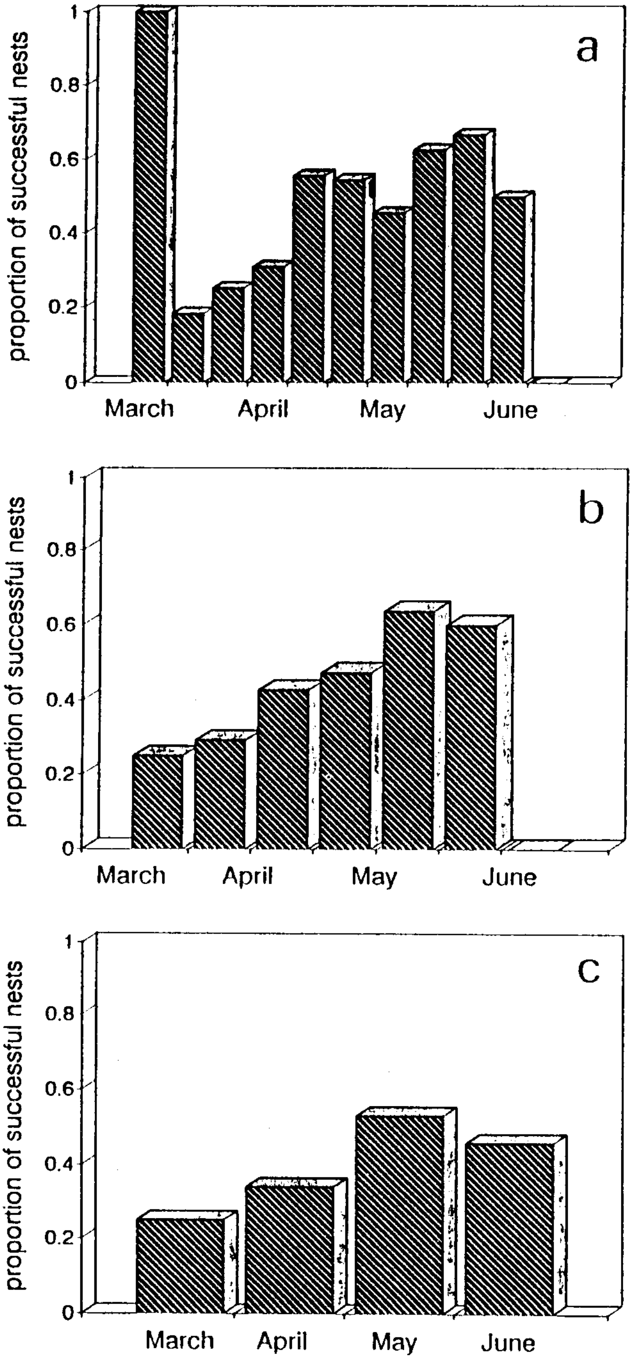

Fig. 3. The proportions of successful nests in 10-day (a), 15 day (b) and 30-day (c) non-overlapping intervals is 1988.

Some authors found that breeding success increased continuously throughout the season (Snow 1955, Havlin 1963, Baum 1968), while others detected an early maximum as well (Ribaut 1964, Dyrcz 1969). One paper described a seasonal pattern with a a maximum in the middle of the season (Koródi-Gál 1967), finally Snow (1969) and Saemann (1979) revealed both an early and a middle maximum in the seasonal pattern.

The differences in the results of these authors are caused by the different arrangement of data. In the following we will demonstrate that these patterns can be produced from the same data-set by modifying both the interval-length and the starting point of the first interval. Figure 3a, b and c show the proportions of successful nests started in 10-day, 15-day and 30-day non-overlapping intervals in 1988, respectively. These kinds of arrangements of intervals can be found in similar studies (e.g., Havlin 1963, Ribaut 1964 and Snow 1969). If the interval-length is quite short (e.g., 10 days, Fig. 3a) then the first few nests - which are usually successful, because predators have not begun to plunder the nests - are sorted into the first interval, consequently their breeding success will be higher than those of the following intervals. However, if we choose a longer interval-length (e.g., 15-days, Fig. 3b) then the first interval will contain more nests than in the previous case, thus the proportion of successful nests will be much lower and the first maximum in the seasonal pattern of breeding success will disappear, althougth the final decrease is still well-expressed. If we choose a quite long interval-length (30 days, Fig. 3c) then the characteristic seasonal pattern of the breeding success found by using 10-day intervals is lost entirely: the early maximum disappears and the final decline in the breeding success is not so expressed, the seasonal pattern tends to be increasing throughout the season.

4. The choice of starting point of the intervals

If we calculate averages in non-overlapping intervals with interval-length L (method 1), we can get L kinds of series by varying the value of m from 0 to L-1. If the change of the parameter is quick at least in a short period of the season, then the series of averages could be quite different.

Example 3: correlations between breeding parameters

Most of the papers which described the seasonal pattern of breeding success, attributed it to the seasonal changes in the rate of predation (Snow 1955, 1969, Koródi-Gál 1967, Dyrcz 1969). Only Ribaut (1964) found the proportion of predated nests similar throughout the season. To settle the question, correlations should be calculated between the proportions of successful and predated nests and between the proportions of successful and deserted nests. However correlations can be calculated only between proportions from non-overlapping periods, otherwise the number of our pairs of points would be artificially multiplied and thus the degree of freedom of the correlation would be seriously violated. Consequently for example if we have the proportions of successful and predated nests in all series of non-overlapping periods (the number of series equals with the interval-length (L)), then L kinds of correlations can be calculated between the two breeding parameters. In the following example we will show that in some cases it depends on the starting point of the first interval (m) whether the correlation between the two proportions is significant or not.

Fig. 4a shows the proportions of successful (filled triangles), predated (asterisks) and deserted nests (empty squares) during

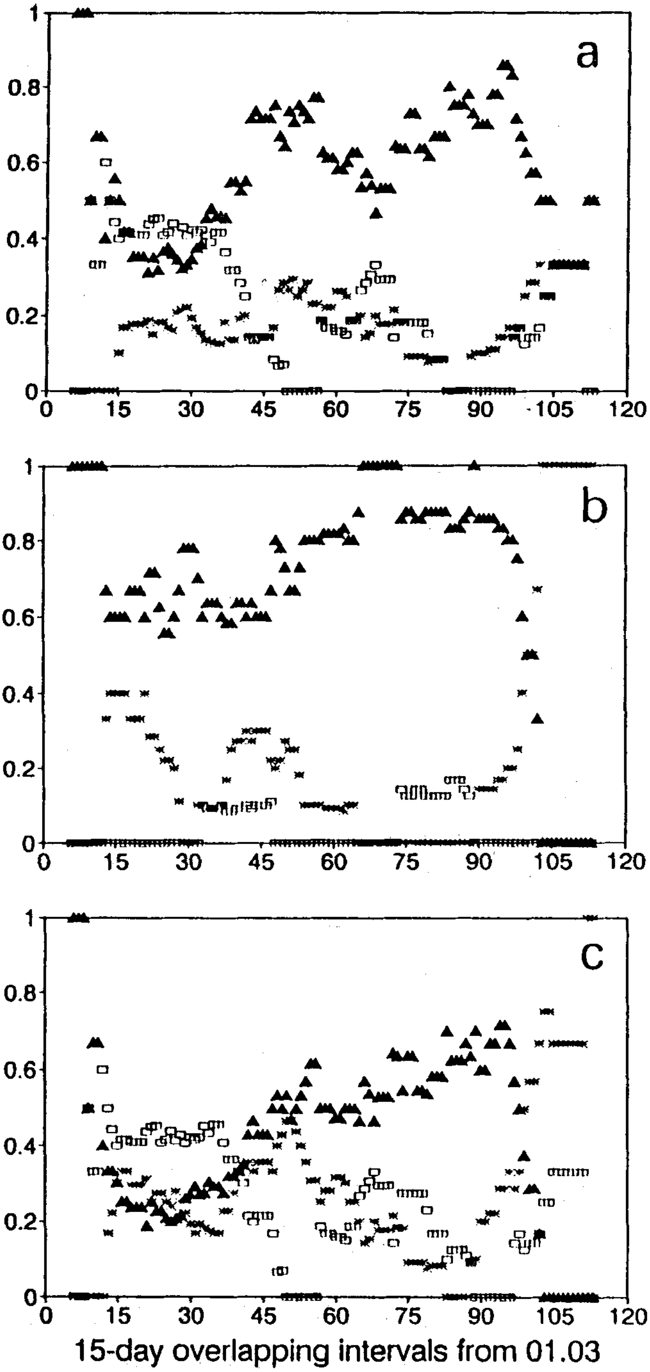

Fig. 4. The proportions of successful (filled triangles), predated (asterisks) and deserted nests (open squares) in 15-day overlapping intervals in 1988 during the incubation periods (a), during the nesling stages (b) and during the whole breeding attempts (c).

the incubation periods in all 15-day overlapping periods, Fig. 4b shows the same proportions during the nestling stage while Fig. 4c shows these proportions during the whole breeding attempt. Consequently Fig. 4a refers to the hatching success, b to the fledging success and c to the breeding success, and if we want to find the causes of their seasonal patterns, we should correlate the proportions of nests in series from non-overlapping intervals. In the case of 15-day intervals, 15 kinds of correlations can be calculated between each pair of parameters. The correlation coefficients are shown in Fig. 5. In the case of hatching success it is always the proportion of deserted nests which correlates significantly negatively with the proportions of successful nests, although the correlations with the proportions of predated nests are also negative but not significant except one case (Fig. 5a). On the other hand in the case of fledging success it is the rate of predation which causes the seasonal pattern: all correlation coefficients but one are significant and most of the correlations with the proportions of deserted nests are positive instead of being negative (Fig. 5b). However in the case of breeding success the result is quite ambigous (Fig. 6c). As the pattern of breeding success is caused by the factors shaping the patterns of hatching success as well as the factors shaping the pattern of fledging success, if the causes are different as in our case, then the pattern of breeding success can be attributed to both predation and desertion. However, it depends on the modification of the starting point (m), whether the correlations with the rate of predation or desertions are significant. This example points out that if we analyse the cause of some seasonal pattern or the correlation between two seasonally changing parameters, then the choice of only one series of non-overlapping intervals can lead to false or ambiguous results.

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Összefoglalás

A mozgó-átlagok módszere a feketerigó (Turdus merula) költési paramétereinek vizsgálatában

A költési paraméterek szezonalitásának kimutatására általánosan alkalmazott módszer, hogy a paraméterek értékeit egymásra következő, nem átfedő intervallumokban átlagolják, és ennek alapján vizsgálják a szezonalitást, illetve állítják a paramétereket egymással szembe. Ez a megoldás több hibalehetőséget tartalmaz: (1) Az időintervallumok hosszának rossz megválasztása nem minden esetben teszi lehetővé az egyébként létező szezonalitás, vagy a paraméterek közötti összefüggés kimutatását; (2) még megfelelő intervallumhossz esetén is, a kimutathatóság függ attól, hogy az első intervallum kezdőpontját hol jelölik ki. A feketerigó egy városi parkban költő populációjának (Vérmező, Budapest 1986-89) költésfenológiai vizsgálatából származó adatokon mutatjuk be ezeket a problémákat. Megoldásként javasoljuk a mozgó-átlagok számításának módszerét, amelynek segítségével az (1) és (2) során jelentkező hiba csökkenthető, illetve amelyen keresztül a nem-átfedő intervallumok átlagainak számításával kapcsolatban újabb nehézségek mutathatók ki.

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