METHODS

ELEMENTS NEEDED FOR A CONSTRUCTION OF A POPULATION DYNAMICS MODEL FOR MONITORING PURPOSES

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ABSTRACT

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Modern monitoring work, in all its aspects (reporting of present status, prediction of a future changes, suggestion of management activity), must base on acceptable model of population dynamics. The general model will contain two elements: descriptive and functional parts. This model should be as complete as possible. It means that the model must incorporate results of very differentiated studies carried out in all seasons of a year. Apart from quantitative data obtained by means of long-term breeding bird censuses, migration counts and winter censuses (descriptive part), it is necessary to know about regulation mechanisms and population structure in some aspects (abundance in optimal and suboptimal habitats, territorial and mating system, sex/age composition, survival model), productivity (breeding success) and mortality causes, critical periods in birds life cycle, selection pressure (both natural and of human origin) and homeostatic abilities of population. Knowledge about possibilities and limitations of population homeoststic abilities is a key for construction of the useful model.

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INTRODUCTION

The monitoring studies on bird populations are at very first stage of development. Out of three levels of such work - reporting on present status of bird population, prediction of future development and suggestion of management activity - only the first level papers can be found in the literature. Some comments on the causes of observed trends, predictions and even advises of management have speculative character and do not base on acceptable model of population number dynamics because simply, such model does not exist. Construction of population dynamics model needs, however, a lot of data collected by means of very differentiated methods and years of continuous field work. The model will be created only when since the beginning of work the elements needed for its construction will be obvious for researchers. An aim of the article is to discuss some essential elements of this work.

There are two stages of modelling population dynamics. The first stage contains a descriptive model of number development of the studied population - long-term field studies give registration of number changes of the studied population and show what kinds of long-term trends are observed: oscillations around stable level, one direction changes or cyclic changes of the number of individuals. This stage of knowledge is sufficient for some predictions of the future, but not for giving useful advises to environment managers. For the last purpose the second stage model must be developed - the functional model of population dynamics, based on the knowledge of regulation mechanisms, specially those responsible for homeostasis of natural population of birds. Construction of the second stage model is much more complicated than the first one but uncomparably more useful in management practice.

Most of the students of population dynamics try to publish their data immediately after three-five years of field studies. This phenomenon is understandable as an effect of impatience of sponsors financing environmental studies but conclusions presented in such papers are without real scientific value but only valuable as encouraging sponsors for further support. Preparing or reading the paper based on monitoring field studies one must remember that time span presented there is only a fragment of continuous dynamics of studied population and that the length of this fragment limits justified conclusion very much. Figures 1-3, although fictitious and simplified, illustrate the problem, as they base on the konwledge collected during 32 year monitoring studies on migrants (results of Operation Baltic) and some data from a non monitoring publications.

Figure 1 shows how illusory are the results of five year monitoring observations (O) from a point of view of monitoring study (MS) lasting around 25 years. Different monitoring observations (five year "windows") show drastically different results: pattern at A, C and E "windows" may lead to conclusions that the population is stable (but studied separately do not tell if the level is high or low), B - that there is observed population crash, while D - that the population trend is moderately positive. Out of five presented "windows" only at one (B) there is a visible downward trend of population number while, despite of cyclic population dynamics curve, there is real two decade downward trend (Fig. 2 - MS). Presented above facts are based on real data published elsewhere (Busse 1984, Busse, Cofta 1986). These data show general downward trend in most of migrants studied by means of quantitative catching at the Baltic coast. Mean yearly rate of the trend is 2.8% for the ten most common passerines (similar study by Berthold *et al.* 1986 gives 1.6% rate) and could be treated as dramatical if one would extrapolate this trend for next 25 years - in 2000 year there would be only 2% of 1960s level. But it is necessary to remember that short term cycle found in 60's and 70's can be a fragment only of a long-term cycle. There are some indications that, in at least some species, fifty year cycle can be found (Machalska *et al.* 1967). The result of this finding can be formulated as follows: monitoring project must be planned as a running project for decades or even as the project for ever. Monitoring of the environment should be so permanent as e.g. weather service. Permanent monitoring is able to document changes in bird population reaching evolutional scale (Fig. 3): population level can be different before and after big changes of enivronmental elements, both of natural (e.g. climatic) and of human origin (e.g. changes in agriculture or urbanisation). Some species can change population number to lower level, but other to a higher one. Two evolutional stages can occur even simultaneously at different parts of species area and the same species can show very differentiated population dynamics when various populations are studied,

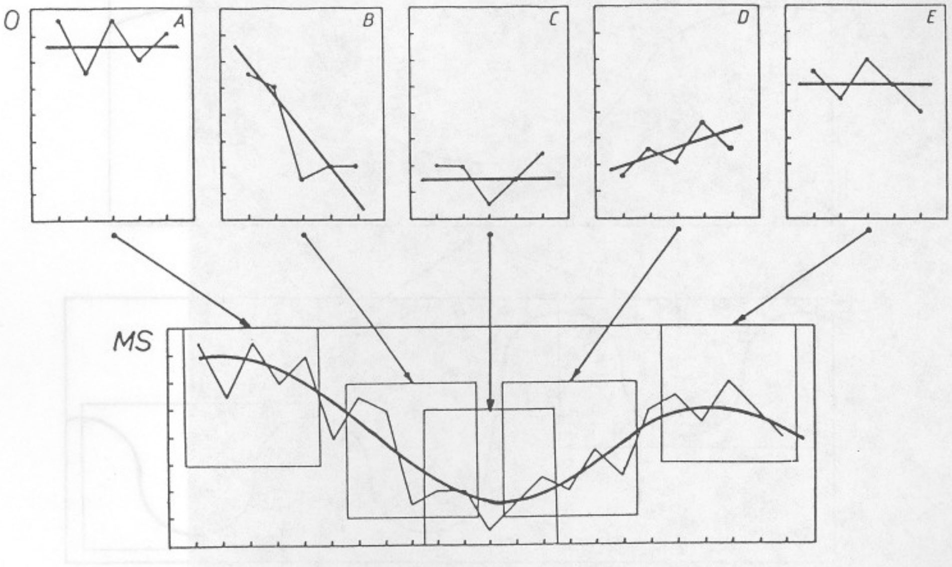

Fig. 1. Interpretation of monitoring data: short-term monitoring observations (O:A-E) and medium-term monitoring study (MS). Thin lines - raw data, thick lines - suggested trends (O) and smoothed curve (MS). Horizontal axis - years, vertical axis - number of birds.

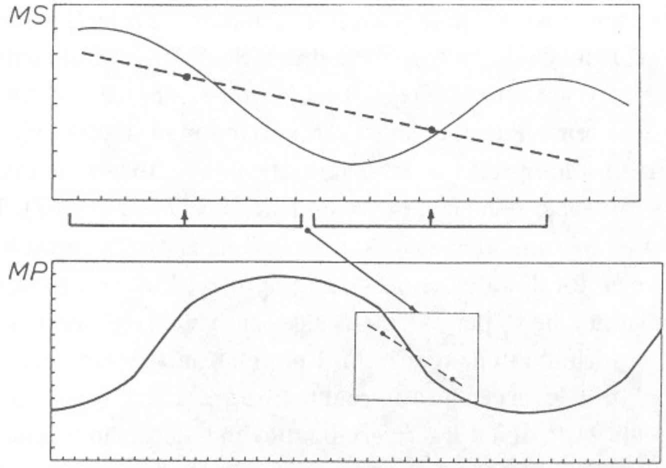

Fig. 2. Interpretation of monitoring data: results of medium-term monitoring studies (MS) interpreted at a background of possible results of long-term monitoring project (MP). Thin continuous line (MS) - short-term cycle, thick continuous line (MP) - possible long-term cycle, broken lines - local, two decade trends.

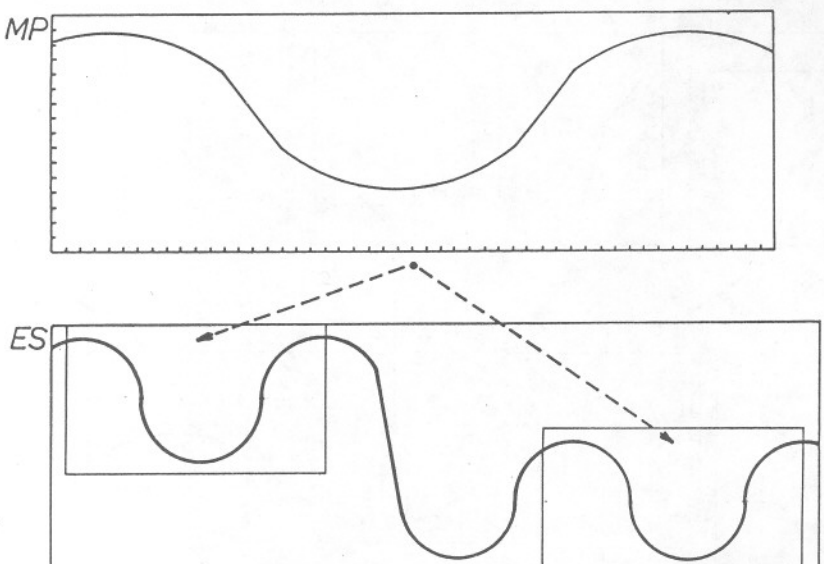

Fig. 3. Interpretation of monitoring data: two levels of long-term cycle caused by evolutional adaptation of population to environmental change. MP - monitoring project scale, ES - evolutionary scale. Continuous lines - long-term cycle, dotted lines - long-term population level.

e.g. response of overcrowded west-european populations of passerines to environmental change can be clearly different from this of more natural and less numerous eastern populations. It must be stressed here that monitoring studies should be carried out at a continent scale. A field method of collecting of data (breeding bird census, winter census or migration count) is here less important than magnitude of the area under the study.

The methods of monitoring become important when one tries to construct the functional model of population dynamics. This is not possible by one method only. It was pointed out during VI International Conference on Bird Census Work at Gottingen, where two previously competing methods - breeding bird census and migration counts - were discussed (Busse 1980). In the mentioned lecture there was presented, at a margin of methodological discussion, a simple model of year round changes of number and variation in bird population with arrows marking checking points of both mentioned parameters (Fig. 4). This model stressed that in monitoring study not only konwledge of number of birds in population, but of dimension of number variation throughout a year is important. Let us look at this model in linear form, more useful for the discussion of elements (Fig. 5). The model assumes one period of growth of the birds number yearly (fledging) and then continuous falling of the number of individuals and continuous reduction of absolute variation. The last statement does not mean the same trend of relative variation in population: relative variation was assumed as growing all year round and then drastically reduced by territorial behaviour mechanisms acting at the beginning of the next breeding season. This model must be corrected as it was oversimplified or even false in some assumptions. The curve representing year round changes of birds number should be corrected (Fig. 6). For many species growth of the number goes through two or more stages (broods). Then, death rate in subsequent parts of yearly cycle is differentiated very much, but for many species not enough studied, while knowledge about terms and size of reduction of the number of population members is essential for finding out populations bottle necks. Localisation in the time of main winter loses is specially important because of direct influence on management activities. After taking into consideration results of spring migration counts (Busse, Cofta 1986), the model must be changed as to presentation of variability of population size (Fig. 7). It was found in the mentioned paper that variability of number of individuals in population in spring is much lower (2.2 - 6.3 times) than in autumn, what means that important stabilising mechanism is active during winter. So, two periods of stabilising processes are known now - in winter and pre-breeding period. It was found too in the mentioned paper, that the coefficient of variation (C.V.) widely used in monitoring studies is not adequate to monitoring data (long-term trends make it fictitious) and must be replaced by another measure of variation. There is proposed coefficient of oscillations as such measure (C.O.). The next step in development of the coefficient adequate to the problem was done in the paper by Busse (1990), where coefficient of fluctuations (CF) was proposed. Figure 8 compares corrected patterns of yearly cycles in number and variability of bird population. These patterns will be surely corrected in future.

Looking at Figure 9 one can find that in yearly cycle of birds life there are some periods where number and variation grow or fall down parallelly or opposi-tively and that changes can be differentiated. These relations are a key to con-struct functional model of population dynamics as they will show bottle neck periods. Clearing of mechanisms responsible for number and variation patterns

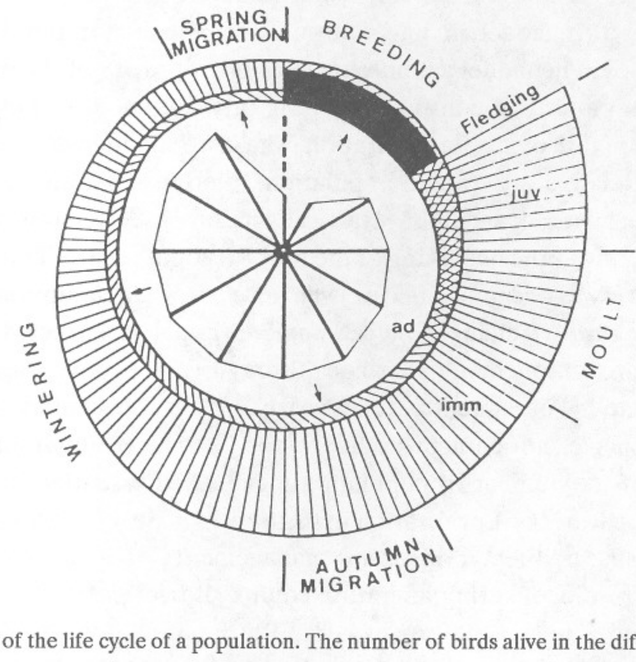

Fig. 4. Scheme of the life cycle of a population. The number of birds alive in the different age classes is shown by the width of the spiral stripes. The central "star" shows the level of variation of population level in various months. Arrows show periods of studies on population level. After Busse 1980.

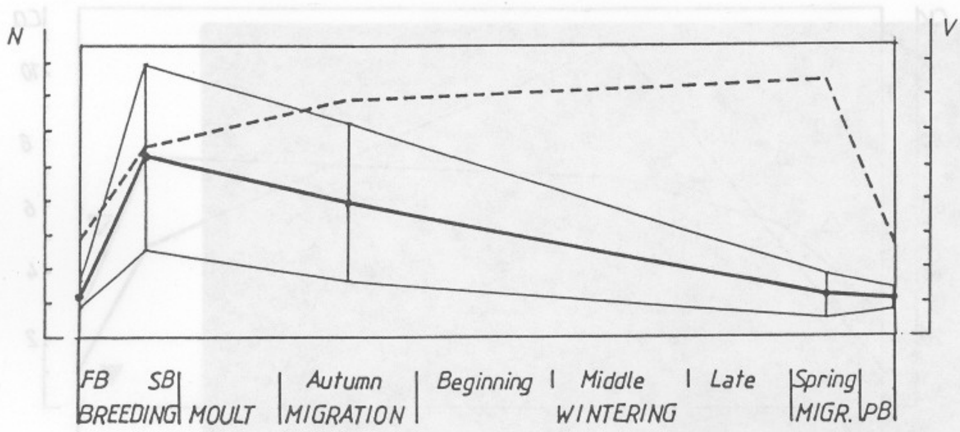

Fig. 5. Scheme of the life cycle of a population, the same as at Fig. 4, simplified. Continuous line - changes of number of individuals (N) in population with absolute variation of number, broken line - relative variation (V) of a population size. More detail division of a year proposed: FB and SB - first and second brood, PB - pre- breeding period.

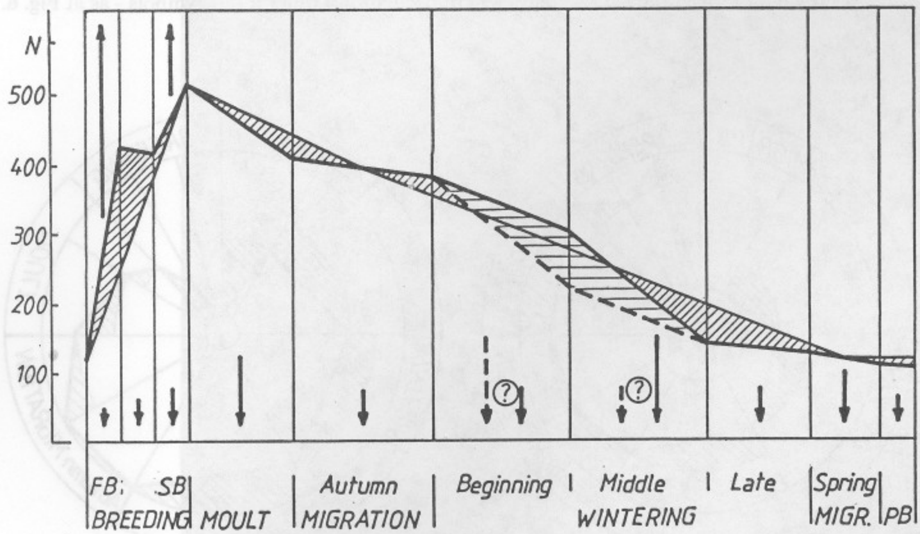

Fig. 6. Corrected scheme of annual changes in population level (N). Thick line (continuous or broken during winter) - number curve corrected in relation to Fig. 5 (thin line); shading points out differences between the curves. Arrows represent growth or reduction rate of the number (quotation marks stress the most important doubts in the size of the rates).

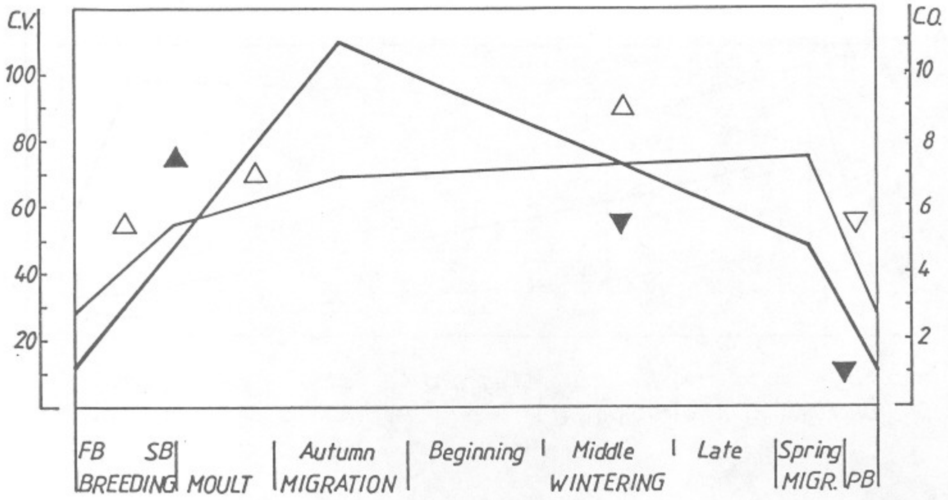

Fig. 7. Corrected scheme of annual changes in relative variation of population size. Thin line (C.V. scale), white triangles - data from the first model (Fig. 4, 5), thick line (C.O. scale), black triangles - corrected data. Triangles point out direction of changes of variation. C.V. - coefficient of variation, C.O. - coefficient of oscillations, other letter symbols - as at Fig. 6.

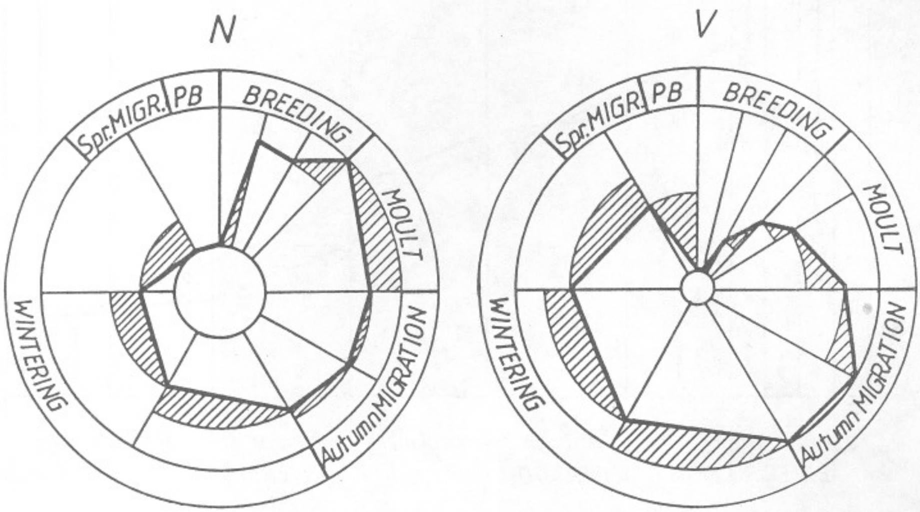

Fig. 8. Number (N) and variation (V) change patterns in a yearly cycle. Shading points out changes between subsequent periods of a year (description of periods simplified in relation to Figs. 5-7).

must base on very different studies and methods depending on a period of birds life and supplying the model with various elements:

Pre-breeding - breeding
- Behavioural studies
  - Territorial behaviour
  - Mating system
  - Population reserve
- Breeding bird censuses
  - Local densities
  - Habitat dependent number and variation levels
  - True population number level ($Np = \Sigma\, nH \cdot SH$)
- Breeding ecology studies
  - Age structure
  - Mortality of adults
  - Production (breeding success)
    - population structure and density dependent
    - habitat dependent
- Mortality causes
  - selection factors
  - human impact

Moult
  - Mortality level
  - Mortality causes
  - age dependent
  - density dependent/independent
- Migrations
  - Population number and variation
  - Sex/age structure
  - Migration status/strategies
- Wintering
  - Winter counts - timing of number/variation reduction

Mortality causes
density dependent/independent
human impact
direct (hunting)
indirect

Comparison of results obtained in different periods of a yearly cycle can supply us with important facts being a basis for conclusions which may be helpful in protection of birds. As an example, there can be shown comparison of results

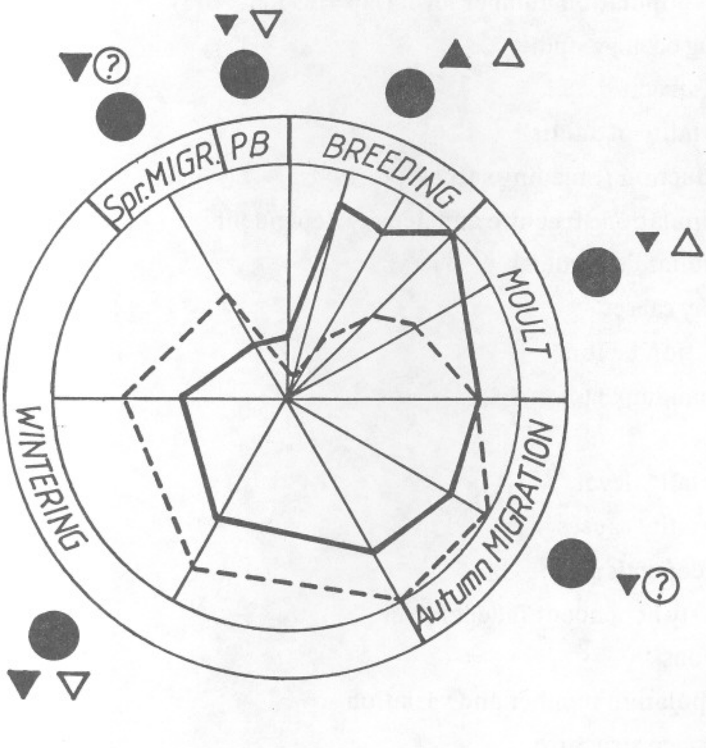

Fig. 9. Relations between number and variation changes in different periods of yearly cycle. Black triangles point direction of a change of number, while white ones - the same for variation. Black circles - periods of different types of monitoring studies. Central figures - simplified patterns from Fig. 8.

obtained by spring and autumn migration counts. Apart from mentioned earlier statement that important stabilisation mechanism acts at winter-quarters (Busse, Cofta 1986), it was found that degree of reduction of population level of African (long-distance) and European (short-distance) migrants is differentiated: for African ones both rates are equal, while for European migrants spring decline rate is clearly bigger than autumn one. It may be interpreted as information that unknown factors over-reduce number of birds wintering in Europe and that homeostatical abilities of these populations are exceeded although density dependent mechanisms of breeding success compensate partly too big number reduction at winter-quarters.

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