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Comparison of bird census methods

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There are several different rationales behind bird censuses and bird census programmes. On one hand they serve the science of theoretical ecology. Reliable quantitative data about the composition of bird communities, the dynamics of species populations, and the geographical distribution of species are mandatory for testing hypothesis about the mechanisms that create and maintain biological associations. The present state of affairs is that we have an abundance of theories in contrast with a severe shortage of hard data, particularly accurate long-term counts. Bird census workers can help to remedy this situation. On the other hand, bird census work serves applied ecology, particularly the fields of nature conservancy and management. In these fields too, there is a strong need for more data, and more appropriate data. For these applied purposes census data are useful in at least the following situations:

1. In the partitioning of land and water between different competing demands.
2. In the management of nature reserves.
3. In the establishment of hunting policies.
4. In the application and enforcement of environmental law.
5. In the evaluation of the effects on the bird fauna of habitat change and other environmental stresses.
6. In the control of effects of management programmes.
7. In the conservation of species populations and bird communities.
8. In general environmental monitoring, that is in using birds as indicators of environmental change (i. e. as components of so called "early warning systems").

Such a broad spectrum of applications in both theoretical and applied fields is parallelled by an equally broad spectrum of ambition levels and census methods. An example is the new Swedish handbook of bird census methods: BIN Faglar (Biological Inventories Norms, Birds), published by the Swedish Nature Conservancy Board. It contains more than ten main methods, each of them with modifications to conform with particular needs. Many other methods and modifications exist in different countries.

The methodological diversity is a necessity, even if we would have liked a higher degree of standardization in order to make comparisons in time and space easier. The progress of science requires flexibility and optimization of the methodological approaches. In the same way, economical factors determine the ambition level of applied environmental studies. Efforts to establish a too small number of standard methods will lead to either that many applications will not be covered by the selected methods, or that the methods will have to be so complex and so costly that they will loose their links with reality.

Even if it is necessary to promote standardization of methods, as the IBCC has tried to do repeatedly (cf. International Bird Census Committee 1969), I am sure that we will see in the future further proliferation and specialization of census methods. But there is a real conflict between the needs for standardization and the needs for flexibility. We cannot hope to be able to operate, for example, large scale monitoring programmes without fairly strict standardization of simple, low cost census and evaluation techniques. On the other hand, we cannot refrain from designing versatile and costly general-purpose methods for solving complex problems, for example when we want to determine the precise population levels of all species of a community. Such general-purpose methods will often consist of a combined set of several different special methods.

In summary, for different aims we need different methods. Nonetheless, there will always be a strong need for using data in integrated studies even if the data were collected by different techniques. This adds up to one important point: We must compare different methods to a larger extent than we have done so far.

Bird census methods

Bird census methods are conveniantly grouped in the following categories.

A. Qualitative methods
   Species listing, as in e. g. atlas work.

B. Quantitative methods
   I. Methods for estimating relative abundances
      1. Line transects
      2. Point or station counts
      3. Standardized area counts
      4. Trapping
      5. Migration counts

   II. Methods for estimating absolute abundances
      1. Intensive studies of populations of individually marked birds
      2. Careful territory mapping of unmarked birds
      3. Application of efficiency conversion coefficients for data originally obtained with "relative" methods (line transects, point counts)
      4. Standardized area counts (some species)
      5. Nest counts
      6. Mark-recapture methods

The categories above are mostly self-explanatory. But a few comments may help to clarify what I mean. Standardized area counts is a category in which I pool methods where the observer covers with his count a specified area but does not apply any of the other methods. The Christmas Counts in North America is such a method. And I have myself used a method where the observer covered units of one square kilometre by just walking around during a specified amount of time in each unit adding up all observations. This category appears both as an index method and as an absolute method. Most often such a method will provide only an index of abundance, such as birds per party-hour (in the Christmas Counts), but for some species the count is so efficient that the result can be considered to be a precise, absolute count (this is probably often the case when counting waterfowl along open coasts and waders on tidal flats). I have also put line transects and point counts among the absolute methods although it is still somewhat doubtful whether the methods for converting the relative indices to absolute densities are yet fully satisfactory.

It is not possible for me to examine the whole complex of method evaluation and comparison here. I will restrict my contribution to some brief comments on a few, arbitrarily selected problems. Other participants will analyse a number of other topics in detail later on at this conference.

Efficiency of standard territory mapping

Results obtained by any method can of course be compared with results from any other method, but such comparisons will be of somewhat limited significance as long as we do not know which method is producing the correct result. This problem is particularly appreciable when the aim of a method is to estimate the true number of birds in a study plot. The territory mapping technique is often used for that purpose, for example when the efficiency of some other method shall be investigated. It is therefore important to know if the territory mapping method really is highly efficient.

The method has been repeatedly questioned (for a summary see Berthold 1976). A part of the criticism refers to applications for which the method cannot be used, for example colonial birds, other birds without "normal" territorial dispersion, etc. But other parts of the criticism remain. For species with low efficiency it is not even after several visits possible to estimate the absolute number of territories in an area. I have recently shown (Svensson 1978) that only if the efficiency of a single visit to a study plot is 50-60 % or higher the full season coverage with 8 or more visits will provide an estimate close to the absolute value of abundance. But many species are less easy to count. The problem of evaluating species maps is also sometimes considerable (Svensson 1974). This depends, according to my experience from species maps returned from census workers in the Swedish Breeding Bird Survey, primarily on the fact that some observers do not care about collecting enough contemporary contacts of birds in neighbouring territories. Most of the problems of cluster separation can be solved if the observer works carefully and slowly enough to collect contemporary contacts between most of the birds having territories close to each other.

There are few attempts to estimate the true efficiency of the mapping method. It is easy to understand why. It is extremely laborious to determine the true abundance of birds, since often it will involve intensive nest-search and colour-ringing. A few years ago Enemar et al. (1976) tried to estimate the efficiency of the mapping technique in a 15 ha birch woodland plot. In two years a group of people worked in the plot in order to count all the breeding birds. They worked for 420 and 300 hrs, respectively, the two years. In the same years standard 10-visit mapping cencuses were carried out independently.

A total of 119 nests of 12 species were found by the group, and 114 territories were mapped, a difference of only four percent. Individual species differed more, however, but the differences were compensating. For example, in the most common species, the Willow warbler *Phylloscopus trochilus*, 35 nests and 48 territories were recorded, and in the next most common species, the Brambling *Fringilla montifringilla*, 39 nests compared with 29 territories. Regrettably there was no colour-ringing of the birds and the group of observers could not establish positively that all nests had been found or that not some territories were defended by males without a nest.

In a later effort to explain the discrepancy for the Willow warbler Enemar et al. (1979) made a new study in the same plot by colour-ringing all the males and mapping their territories in detail by song play-back. They also located most of the nests. At the same time an independent standard mapping survey was made. There were 15 stationary males in the plot, and the same number of territories was mapped, but only 11 nests were found. Hence, an explanation to the discrepancy in the first two years is perhaps that all the nests were not found in spite of the considerable work investment. But another explanation was also indicated. In two cases one territory had been interpreted as two in the evaluation of the standard mapping census. Multiple song-posts thus may cause trouble as previously found by Jensen (1971-1972, 1974) for the Whitethroat Sylvia communis and other species. This is probably a common source of error among species with large, peripherially defended territories. Further studies of this kind are badly needed.

Line transects versus territory mapping

When trying to evaluate the efficiency of line transects (and point counts) two approaches have been used. One is to assume that all birds are recorded in a narrow zone along the track of the observer, and then to construct a suitable model for including the birds observed in the zone or zones outside this central zone. In the Finnish line transects it has been assumed that all birds are observed in the so called main belt (25 m on each side of the line) and a linear model is applied for using data from outside the main belt (Järvinen & Väisänen 1975, Järvinen 1976). To assume that there is 100 percent efficiency in the narrowest zone along the line is no solution to the efficiency problem, only a way to avoid solving it. One cannot assume uncritically that all birds are observed in the zone. Besides, if the central zone is made narrow enough to ensure 100 percent efficiency, if this were possible, the unavoidable interactions between the birds and the observer will cause new difficulties. The other way to conpensate for the inefficiency of a transect count is to carry out line transects in an area with a known population in order to obtain conversion coefficients. This method has been used in France to find correction coefficients for point counts (Ferry & Frochot 1970, Frochot 1971, Frochot et al. 1977).

The efficiency of line transects was studied by Järvinen et al. (1978) in areas simultaneously surveyed by the territory mapping method. They found surprisingly high efficiencies, between 67 and 103 % for the whole community in the main belt. For the Willow warbler the average main belt efficiency was 101 %, which is much higher than the visit efficiency of a mapping census (the ratio between the number of males recorded in one visit and the number of evaluated territories), which is about 70 %. These two figures ought to be similar since the time investment per unit area are approximately the same for one mapping visit and one line transect (about 20 minutes per hectare).

A probable explanation for the surprisingly high efficiencies obtained by the transect method is that the owner of a territory is more easily counted close to the observer than further away. A single territory is often large compared with the 50 m zone of the line transect and many territories lie partly outside this zone. Birds move about in their territories, and therefore there is an apparent risk of including territories more often than their share of the census zone justifies. The bias may increase further if there is an interaction between birds and observer so that birds move from a distant position in the territory to one closer to the observer when he passes. Further studies of line and point transect efficiencies in areas with known populations are needed.

Often the aim of a census programme is not to determine absolute densities but only to monitor fluctuations or to establish relative population levels. Then the line transects and the point counts have the advantage that large areas can be covered and information can be collected about a great number of birds. For a number of years we have made territory mapping in three alpine plots (2, 24 km^2) and extensive line transects over much larger areas in the surrounding region. The total number of birds of all species shows a good agreement between the two methods, but when we look at single species the picture is different for some of them. In the most abundant species, the Meadow pipit Anthus pratensis, there is for example no correlation, whereas in the Willow warbler there is a strong correlation (Fig. 1).

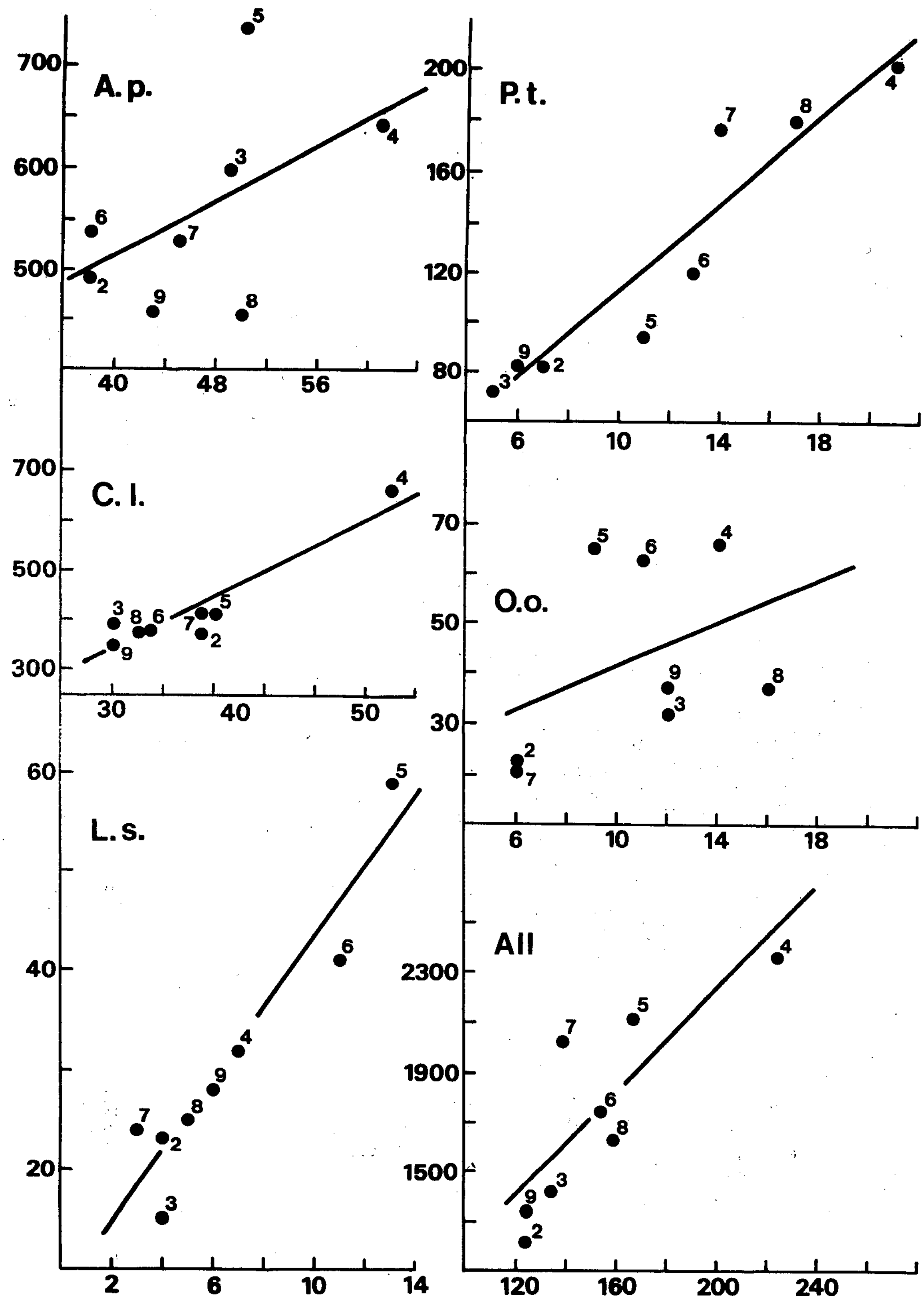
In this case it is not possible to draw any firm conclusions from the experiment, since the line transects were not carried out exclusively within the mapped plots. But the habitats are uniform, and there are no reasons from that point of view to expect that the density variations in the study plots should differ from those elsewhere. We believe instead that the activity of the birds plays a major role in causing the discrepances. In these open and easily surveyable study plots day to day changes in the activity of the birds are of minor importance since the plots are walked very carefully at each visit, and the birds are searched for actively if they do not sing frequently. This is not the case when making line transects.

An important question in comparing different methods is the speed with which information can be collected. Over eight years, 1972 through 1979, we counted 14 687 birds during 15 515 minutes of line transects, i. e. about one bird per minute. During territory mapping in the study plots in the same habitat we used an average of 73 hours a year for mapping an average of 88 pairs or territories, i. e. about one territory per hour. Thus during the line transects we counted 50 birds for each territory we established in the mapping plots. But a great sample is more useful than a smaller one only if it is not biased and if it has a smaller relative variation. And about this we do not yet know enough to draw any final conclusions. In line transects (and in point counts) we also have the additional problem of not being able to distinguish between territory holders and floaters (including migrants taking up temporary territories).

Point counts versus territory mapping

I have recently taken part in a small study of point counts in a plot that was also censused by the mapping technique. The plot was divided into 22 squares of 100x100 m each. In the center of each square we made 5-minutes point counts. Each of two observers made two visits a few days apart, thus collecting a total of 4x22=88 point counts. The birds were recorded within 25 m, between 25 and 50 m, and beyond 50 m. We found it difficult to determine unambiguously these distances, an experience that other people also have gained. On the average, 19 % of the birds within 50 m were recorded within 25 m. The expected value if we assume equal detectability up to 50 m is 25 %. There was however considerable variability between days and observers (Table 1).

For the Willow warbler we recorded an average density (uncorrected) of 116 males/ km^2 within 25 m and 131 males /km^2 between 25 and 50 m. The value obtained by the mapping census in the plot was 79 territories/km^2, i. e. much lower. Thus the point counts almost certainly overestimated the density in this case. We also overestimated the Brambling and the Tree pipit Anthus trivialis. The Dunnock



A. p.
700
600
500
40
48
56
P. t.
200
160
120
80
6
10
14
18
C. l.
700
500
300
30
40
50
O.o.
70
50
30
6
10
14
18
L. s.
60
40
20
2
6
10
14
All
2300
1900
1500
120
160
200
240

Fig. 1: Correlation between the number of territories in study plots (x-axis) and (left) the number observed along line transects (y-axis). Key: A. p. = Anthus pratensis, C. l. = Calcarius lapponicus, L. s. = Luscinia suecica, P. t. = Phylloscopus trochilus, O. o. = Oenanthe oenanthe, All = All species. The correlation coefficients were for A. p. 0.52, C. l. 0.94+, L. s. 0.94+, P. t. 0.94+, O. o. 0.40, and All 0.84+. A plus sign indicate significance ($p < 0.05$). Figures close to the dots denote year: 2 = 1972, 3 = 1973, etc.

Abb. 1: Beziehung zwischen der Anzahl von Territorien auf Probeflächen (x-Achse) (links) und der Anzahl entlang von Linienerhebungen (y-Achse). Schlüssel: A. p. = Anthus pratensis, C. l. = Calcarius lapponicus, L. s. = Luscinia suecica, P. t. = Phylloscopus trochilus, O. o. = Oenanthe oenanthe, All = alle Arten. Die Korrelationskoeffizienten betrugen für A. p. 0,52, C. l. 0,94+, L. s. 0,94+, P. t. 0,94+, O. o. 0,40, für alle Arten 0,84+. Das Plus bezeichnet statistische Signifikanz ($P < 0,05$). Die Zahlen neben den Punkten geben die Jahre an: 2 = 1972, 3 = 1973 usw.

Table 1: Percentage of birds counted at different distances from the observer in 5-minutes point counts.

Tabelle 1: Prozentsatz von Vögeln, die in verschiedenen Abständen vom Beobachter in 5-Minuten Punktzählungen gezählt wurden.

Observer	Date	Distance: < 25 m	% observations 25-50 m	> 50 m	No. of birds	No. < 25 m in % of no. < 50 m
S	16 June	4	35	61	193	11
S	19 June	6	27	67	171	18
N	23 June	9	19	72	162	31
N	25 June	6	17	77	158	25
S	both	5	31	64	364	14
N	both	7	18	75	320	28
Both	all	6	25	69	684	19

Table 2: Density estimates(Males/km^2) obtained from point counts and from territory mapping.

Tabelle 2: Dichteschätzungen (Männchen/km^2) aus Punktzählungen und Revierkartierungen.

Species	Density, Point counts < 25 m	25-50 m	Density, territory mapping
Phylloscopus trochilus	116	131	79
Fringilla montifringilla	41	54	37
Anthus trivialis	-	23	14
	17		
Prunella modularis	6	21	37
	17		

Prunella modularis was, on the other hand, underestimated (Table 2).

Obviously, the information indicates that further work is required before we can use line transects and point counts for independent density estimates. One particularly important question to study is the variation among different observers when they estimate the distance to a bird seen or heard along the line transect or from the point.

Line and point transects as index methods

An important question when chosing between line transects and point counts for a monitoring programme is which method is the most economical. In most respects the two methods should be comparable since a point count is nothing but a line transect that is interrupted for certain periods during which the observer moves from one point to another. I made a small study of this problem by walking and collecting line transect and point data simultaneously. Five minutes line transects alternated with five minutes stops along the same route. A total of 47 stops and 45 5-minutes line transect sections gave the same average number of species, 8.2, and almost the same number of individuals, 21.0 and 23.1. From this it can be concluded that the two methods are comparable when only the active counting time is considered. The time for transport between the stops can then be added, and it is then obvious that the point count method is about 2-3 times less efficient than the line transect method, since it normally takes 5-10 minutes to move from one stop to the next if the stops should be distant enough from each other to ensure that the number of double counts is maintained at a low level.

It is not certain however that this is a correct comparison. Line transect counts may be more variable than point counts. During a line transect the observer must be equally alert all the time to provide data with the same variance as from a point count. In the latter case there is no difficulty to be fully alert all the time since the active counting periods are interrupted, which allows the observer to rest mentally. Walking in itself in a line transect is a disturbing factor unless the speed is low enough to allow frequent brief stops. The relative variance of comparable censuses with the two methods should be studied in order to evaluate their relative merits fully.

Some special problems

Finally I will discuss briefly two further questions. The first is the problem of censusing species with territories that are much larger than normal census plots. Such species are often counted very inaccurately when they occur in a plot since a part of the territory may lay outside the plot. And even within an extensive census programme with many plots they may be recorded with so few territories that accurate estimates of densities or density changes cannot be made. Too few studies of such wide ranging and rare species are available. I would urge people to initiate census work of that kind. When counting such species, common species must probably be excluded from the census or censused only in a part of the study area. Nonetheless it is important to obtain information about this kind of species, for which the census problems and consequently perhaps also the census methods may be different.

The second problem that I will draw attention to is the issue that Ludwik Tomialojć has adressed, the problem that the traditional territory mapping method does not satisfy the methodological requirements for censusing all species in a plot. He has proposed the design of "a combined version of the mapping method".

The international standard for a mapping method was designed many years ago, when the experience of the method was limited. The need we felt at that time was to ensure standardization and comparability of data. The aim at that time was mainly to design a method that could be applied as a monitoring instrument. We did not care so much about the efficiency of the method for different species. In our opinion it was important to be able to collect reliable index values of species population changes even if the data could not be used directly in providing estimates of absolute population size. Tomialojć has said that he feels that the present standard is too rigid to cover the variety of species and habitats when the aim is to collect true density estimates. I agree with him, and I think a valuable contribution to the art of bird count would be, if this conference could initiate a study aimed at the establishment of an alternative, more flexible mapping method for those census workers who need more accurate density estimates than the present method can provide in all situations. Such a method would have to consider the behaviour of individual species, the different lengths of the season at different latitudes, the different degrees of detectability of birds in different habitats, and the inclusion of supplementary methods for species that cannot be censused by territory mapping.

Bird census work is now, after the ten years since we started the work within the International Bird Census Committee and after five conferences of this kind, in a state when we are beginning to understand more fully the relative merits of different methods, what they can do and what they cannot do. Still more interesting and more challenging is the importance that is given good, hard data provided by bird census workers, both by theoretical ecologists and by people working in the field of applied environmental science. This conference is a further step in the process of providing a firm scientific basis for bird censuses and their applications.

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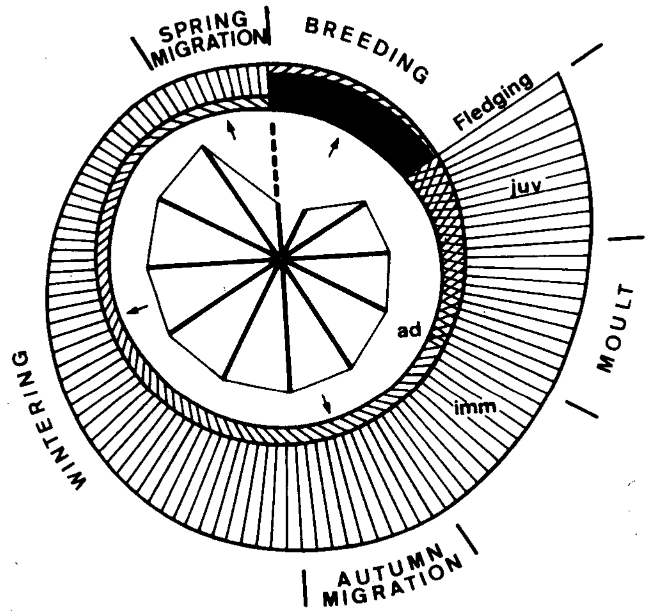

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