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SOURCES OF ERROR INVOLVED IN THE FINNISH LINE-TRANSECT METHOD

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ABSTRACT.—The line-transect method has been used extensively in Finland for estimating numbers of land birds, but only a few attempts have been made to test its efficiency and reliability. The present paper examines the applicability of this census method to (1) estimating absolute densities, and (2) studying changes in bird populations.

Single line-transect censuses were compared with careful mapping of pairs and searching for nests on two study plots in Finland. In both tests only 46–49% of the breeding pairs were recorded in the single censuses. Similar tests restricted to seven selected species in three study areas gave similar results: the census efficiency ranged from 33 to 67%, averaging 48%. The reliability of the line-transect method was tested further by letting one person census the same transect several times throughout the breeding season: the numbers of pairs of most species varied greatly from one census to another, the maximum being often 3–5 times higher than the minimum. Consequently, the published density values, biomass and energy flow calculations, and estimates of the total numbers of pairs in Finland, based on line-transects, must be considered unreliable; most of them are serious underestimates.

The unpredictable outcome of single line-transect censuses also reduces the reliability of apparent annual population fluctuations detected by this method. This is especially true if there are between-year differences in (1) census takers, (2) dates of censuses, (3) weather conditions, or (4) proportions of different habitats. A good example is provided by the recent population trend of Finnish Starlings: the species is known to have decreased catastrophically in the 1970s, yet the extensive line-transect material did not reveal any such change. Least safe are comparisons between old and current censuses because of several additional factors, like (1) advances in field ornithology, (2) different working methods, (3) scanty data, and (4) influence of exceptional census years, all of which could bias the results.

The line-transect method has been used extensively in Finland for estimating numbers of land birds. A pioneer in this field of ornithology was Prof. E. Merikallio, who censused more than 1000 km of transects in the 1940s and 1950s (Merikallio 1946, 1951, 1958). In the 1970s, Drs. O. Järvinen and R. A. Väisänen revived the line-transect censuses in Finland and collected material covering over 3000 km of transects. In many stimulating papers they have presented and discussed their data (e.g., Järvinen and Väisänen 1980, and the literature cited there).

In contrast to the impressive amount of work providing the Finnish line-transect material, our knowledge of the efficiency and reliability of the method is poor. Although its weaknesses have been generally recognized, only a few attempts have been made to test quantitatively the influence of the various sources of error upon the results. This lack of information naturally reduces the confidence that can be placed in them. How valid are, for instance, the bird density values for different habitats, estimates of the total numbers of pairs in large regions, or long-term trends in the avifauna, based on line-transect censuses?

In his extensive review of bird census methods, Berthold (1976) has emphasized correctly that only reliable methods should be used and that the sources of error involved in the methods should be critically tested. The same views had already been clearly expressed by Palmgren (1930). The aim of the present paper is to examine the applicability of the line-transect method to (1) estimating absolute densities, and (2) studying annual and long-term changes in bird populations.

METHODS

The methods of the Finnish line-transect censuses have been described in detail by Järvinen and Väisänen (1976c), so only a few facts need to be stressed here. Each transect is counted only once, during the month of June, between 04:00 and 09:00. The birds observed within 25 m on both sides of the transect are included in the *main belt*, those registered farther away belong to the *supplementary belt*; together, the two belts form the *survey belt*. Bird densities are estimated in general from the survey belt data, using a correction method based on a linear model (Järvinen and Väisänen 1975, 1976c).

The efficiency of the line-transect method, or any other census method based upon a single visit to a study area, can be tested most reliably by comparing the census results with the true numbers of stationary birds. The true composition of the bird community within a certain area, in its turn, can be figured out best by careful mapping of pairs and searching for nests throughout the breeding season, preferably combined with color-ringing.

In this paper, five such tests are reported. In two of them the entire community of a study plot was censused, while three tests were confined to two or three dominant species of the habitat. In all these investigations, the independent single transect counts were

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TABLE 1

CENSUS EFFICIENCY OF THE LINE-TRANSECT METHOD ON A STUDY PLOT OF 5 HA OF MIXED WOODLAND IN KIRKKONUMMI, S FINLAND (O. HILDÉN & L. J. LAINE). THE RESULT OF A SINGLE CENSUS ON 17 JUNE IS COMPARED WITH THE TRUE NUMBERS OF PAIRS IN 1980

Species	True numbers	Single census
Fringilla coelebs	6	4
Ficedula hypoleuca	6	4
Phylloscopus trochilus	5	3
Erithacus rubecula	5	2
Apus apus	4	—
Parus major	3	3
Turdus philomelos	3	1
Prunella modularis	3	2
Carduelis spinus	3	1
Other species (15)	19	8
Total no. of pairs	57	28 (49%)
Total no. of species	24	14 (58%)

TABLE 2

CENSUS EFFICIENCY OF THE LINE-TRANSECT METHOD ON A STUDY PLOT OF 60 HA LUXURIANT MARSH IN KARIGASNIEMI, FINNISH LAPLAND (O. HILDÉN). THE COMBINED RESULTS OF ANNUAL SINGLE CENSUSES IN LATE JUNE ARE COMPARED WITH THE TRUE PAIR TOTALS IN 1969–71

Species	True numbers	Single census	Efficiency (%)
Anthus pratensis	90	25	28
Phylloscopus trochilus	59	33	56
Calcarius lapponicus	57	31	54
Motacilla flava	35	27	77
Luscinia svecica	35	6	17
Carduelis flammea	32	14	44
Emberiza schoeniclus	20	11	55
Limicola falcinellus	19	6	32
Phalaropus lobatus	19	6	32
Tringa glareola	16	9	56
Other species (11)	52	32	62
Total no. of pairs	434	200	46
Total no. of species	57	50	80

made by experienced census takers, in favorable weather conditions and using the standard rules of the Finnish line-transect method. Information on slight modifications of the normal field procedure used in some of the tests, as well as relevant details of the locality, habitat, census, etc., are given in the text.

The efficiency of the line-transect method can also be tested in another way, by counting the same transects several times in the course of the season and comparing the results of the successive censuses with each other and with the maximum numbers recorded along the routes. Such experiments were organized in 1979 by L. J. Laine at three localities in southern Finland. Each transect was surveyed by the same person (T. Ahlström, P. Koskimies, L. J. Laine), using standardized methods and in optimal weather at about 10-day intervals from mid-May to early July, six times in all. Survey belt data were used in this case, partly to avoid the biases caused by small samples, partly because the main objective of these tests was to examine the constancy of successive transects in the course of the season.

CENSUS EFFICIENCY

One of the two community censuses was made on my own property, consisting of 5 ha of mixed woodland in southern Finland, about 30 km west of Helsinki. In 1980, I determined the numbers of its breeding birds very carefully by daily observation throughout the breeding season; about two-thirds of all nests or broods were found. On 17 June, between 04:55 and 05:40, an independent transect count was conducted by L. J. Laine, who walked along a zigzag route so that the total area was covered as well as possible by the main belt. As shown in Table 1, only 49% of the pairs and 58% of the species were recorded in this single census.

The other study plot in which a similar test was made is of completely different habitat—a luxuriant marsh of 60 ha in Finnish Lapland. In 1966–72, it was the main research area during my study on subarctic bird communities and was surveyed almost daily by several students from early June to mid-July. The estimate of the numbers of pairs was based on nests found in almost half the instances, otherwise on careful observation of the birds. In three summers, in late June, an independent single census was conducted jointly by three students, who crossed the marsh walking side by side along parallel transects, first through one half and then back through the other so that the whole area was surveyed. The distances between the counters (30–80, average 60 m) were slightly greater than the main belt width (50 m) in normal line-transects, but this was compensated by the open habitat, which made it easy to observe the birds. The results, summarized in Table 2, show that, on average, 46% of the pairs were recorded in the single censuses; for some species the efficiency was as low as 17% in the Bluethroat (*Luscinia svecica*) and 28% in the Meadow Pipit (*Anthus pratensis*). Far fewer species were missed than in the wooded habitat.

The three other tests were confined to selected species whose numbers of pairs in the study areas could be estimated accurately by means of nests found, color-ringing, and careful observation of the birds. The results are summarized in Table 3, which also gives some additional details of the censuses. It should be noted that

TABLE 3
CENSUS EFFICIENCY OF THE LINE-TRANSECT METHOD FOR SELECTED BIRD SPECIES IN THREE STUDY AREAS IN FINLAND; THE MEANS OF SINGLE TRANSECTS (NO. IN BRACKETS NEXT TO AREA) IN JUNE ARE COMPARED WITH THE TRUE NUMBERS OF PAIRS

Area and species	True no. of pairs	Mean of transects	Efficiency (%)
Pori 1968 (6)[a]			
Emberiza schoeniclus	16	7.5	47
Acrocephalus schoenobaenus	8–9	2.8	33
Kirkkonummi 1979 (2)[b]			
Parus major	19	9.5	50
P. caeruleus	6	2.0	33
Ficedula hypoleuca	10	5.5	55
Valassaaret 1980 (3)[c]			
Anthus pratensis	>18	9.3	<52
Oenanthe oenanthe	9	6.0	67

[a] Census taker: Haukioja (1968). Size of the area: 5 ha. Habitat: willow thickets, meadows and reeds. Method: normal line-transect, only main belt data used.
[b] Census takers: O. Hildén & L. J. Laine. Length of the transect: 3.5 km, with 39 nest-boxes placed within the main belt and 3 slightly outside. Habitat: mixed woodland. Method: normal line-transect, survey belt data used.
[c] Census taker: T. Pahtamaa. Size of the area: c. 50 ha. Habitat: scrub heathland. Method: line-transect along a zigzag route, average width of the census strip 65 m.

survey belt data (i.e., all observations) were used in the census of box-nesting species in Kirkkonummi, although almost all their nests were situated within the main belt. If only main belt registrations were used, the efficiency percentage for these three species would drop to 32, 17 and 45, respectively. In the study plot censuses at Valassaaret, the average width of the strip (65 m) slightly exceeded the main belt (50 m) in ordinary line-transects but, on the other hand, the openness of the habitat, low bird density and concentration on only two species considerably facilitated the counts. Although the three tests concerned different species, living in different habitats, the results are fairly consistent, showing that between 33 and 67% (average 48%) of the stationary pairs were recorded in the single line-transects in June.

The results of successive counts of the same transects are shown in Table 4. For almost all species, the numbers of pairs counted varied greatly from one census to another, the maximum being often 3–5 times higher than the minimum. The numbers of Chaffinches (*Fringilla coelebs*) proved least variable between censuses, while those of Robins (*Erithacus rubecula*) were most variable (maximum: minimum = 1.4 and 8.4, respectively). This finding reveals the degree of unpredictability of a single census for each species, but does not tell us much about its accuracy in relation to a true population estimate. A rough calculation of this can be made in the following way:

The length of all the line-transects was 4 km, and observations were recorded separately for each kilometer. By summing the highest numbers recorded within these quarters in any census, an estimate of the maximum numbers of pairs along the whole transect was obtained; this value was 19% higher, on average, than the highest value for a single count. As even the best censuses are likely to be underestimates, some birds being always overlooked, these "maximum numbers" may serve as rough estimates of the true populations. The census efficiency was then estimated by comparing the results obtained in June (the recommended period for line-transects in Finland) with the maximum numbers of pairs. This gave a mean efficiency of 47%.

This result is in good agreement with those from the study plot censuses reviewed earlier. The conclusion is that even in favorable conditions an experienced observer will record, on average, about half of the stationary birds present in a study area, if using a single line-transect census. Thus, the efficiency of single transects is comparable to that of single counts in the mapping method, which has been estimated at about 50% (Enemar et al. 1978). The low efficiency of the line-transect method should not surprise ornithologists familiar with the poor detectability of most bird species during certain phases of their breeding cycle. Indeed, an even lower efficiency has been reported by Lehtonen (1979). For about 30 years, he has made extensive tests to compare the accuracy of the different methods used to census land birds, and concluded that in forest habitats in southern Finland at best 25–40% of the stationary birds within the main belt are recorded in line-transects.

All the tests reviewed here thus prove convincingly that the conclusion of Järvinen et al. (1978a) that between ⅔ and ⅚ of the birds within the main belt are recorded in single line-transect censuses is far too optimistic. Such a high efficiency can be reached only in exceptionally suitable habitats under optimal conditions, as in the test made by Järvinen et al. (1978a) in mountain birch forest. In addition, the line-transects in this test were compared only with the mapping method, which tends to underestimate population densities (e.g., Nilsson 1977b, and the literature cited there), not with the true numbers of pairs; this probably also contributed to the high apparent census efficiency obtained.

In itself, the low efficiency of the method would not be a serious argument against the use of single line-transects, if the efficiency remained more or less constant (1) from species to species, (2) from one observer to another, and (3) during the census period. If this was the case, the results could be transformed easily to real densities by using a correction coefficient. But this cannot be done, because there are such striking differences in detectability among species (Table 4) and in the capacity to observe birds between census takers; moreover, the detectability of the species fluctuates in different ways during the course of the season. The latter fact was shown convincingly in successive censuses of the same transects, and some examples are depicted in Figure 1. Pronounced seasonal patterns in census efficiency of certain species were also found by O'Connor (1980c) in an experimental investigation of the effects of census date on the results of Common Birds Census surveys.

What is particularly striking, when one analyzes the results of the repeated counts of the same transects, is that the best census period for most species in southern Finland is the latter half of May, i.e., before the time recommended for line-transects. With few exceptions (*Turdus merula, Fringilla coelebs*), this was true of all sedentary species and all migrants arriving by mid-May. For some resident birds, such as titmice, a reliable census presupposes still earlier counts, started in March-April (Nilsson 1977b). The only species that are censused better in June are the few late migrants, such as *Phylloscopus sibilatrix, Sylvia borin* and *Muscicapa striata,* which arrive in Finland from mid-May onward. The superiority of May counts for most species is also indicated by the fact that the results of the three simultaneous transects were in general more consistent in May than in June, obviously because higher detectability reduces the effect of mere chance. This finding also strongly suggests that transient birds were not included in the May counts, as then, on the contrary, the numbers should have varied more from sample to sample than later in the season.

A logical consequence of the line-transect tests reported here is that all the published density values, biomass and energy flow calcultions, and estimates of the total pair numbers in Finland, based on this census method, are unreliable; most of them are serious underestimates.

ANNUAL CHANGES IN BIRD POPULATIONS

In recent years, line-transect data have been used in several papers by Järvinen and Väisänen (e.g., 1977b, 1977d, 1978b, 1978c, 1978d, 1978e, 1979a) also for studying annual changes in the avifauna. This may appear a useful approach, even if the weaknesses of the method are recognized, as the sources of bias and error can be expected to remain more or less constant from year to year. However, a detailed consideration reveals that results obtained by comparing annual line-transect data may give a seriously misleading picture of population trends. In the following paragraphs, I will comment briefly on the most important sources of error involved in this approach.

1. Unpredictability of single line-transects.—As shown by successive censuses of the same transects, the numbers of pairs counted vary greatly, not only between the different phases of breeding cycle but also between two consecutive counts conducted a few days apart. Particularly when small amounts of data are compared, considerable apparent differences between the annual density values may be attributable to this factor alone.

2. Differences between census takers.—There are considerable differences among ornithologists in their capacity to detect and identify birds, as revealed by several tests concerning both censuses of breeding birds (e.g., Enemar 1962, Snow 1965, Hogstad 1967, Berthold 1976, Enemar et al. 1978) and counts of migrants (e.g., Enemar 1964, Källander et al. 1972, Källander and Rydén 1974). Consequently, apparent annual differences in the numbers of birds recorded by different persons on line-transects may in fact reflect differences between the census takers rather than real changes in bird populations.

3. Different dates of censuses.—As shown in this paper and by several earlier students (e.g., Slagsvold 1973c, 1977; Berthold 1976; and the literature cited in these), the song activity and thus the census efficiency for a particular species depends greatly on the phase of its breeding cycle. Even small annual differences in the timing of the censuses relative to the breeding cycle may thus affect considerably the results obtained, and longer time differences can be expected to mask completely the true population changes of most species.

4. Different weather conditions during the censuses.—The detectability of birds is greatly influenced by weather conditions (e.g., O'Connor and Hicks 1980). Although the standard rules for line-transects presuppose good census weather, complete accordance in this respect is never reached. The effect of this factor cannot be measured reliably.

5. Different proportions of various habitats in the samples.—Unless permanent line-transects are used, the different habitats are seldom represented by the same proportions in successive annual samples. This is especially true of more scarce habitats showing a patchy distribution. The result is that the occurrence of a number of the more locally distributed species on the transects is affected.

TABLE 4

CONSTANCY AND EFFICIENCY OF SINGLE LINE-TRANSECT CENSUSES IN THE COURSE OF THE BREEDING SEASON; COMBINED RESULTS FROM THREE TRANSECTS IN S FINLAND, 4 KM EACH, COUNTED SIX TIMES FROM MID-MAY TO EARLY JULY AT ABOUT 10-DAY INTERVALS; ONLY THE 20 MOST ABUNDANT SPECIES ARE CONSIDERED

Species	Maximum numbers of pairs[a]	Recorded numbers of pairs		Census efficiency in June[b]		
		Lowest	Highest	Lowest	Mean	Highest
Fringilla coelebs	213	140	202	71.8	79.8	86.9
Phylloscopus trochilus	133	61	121	45.9	66.7	82.0
Erithacus rubecula	72	7	59	9.7	31.0	56.9
Turdus iliacus	59	17	52	47.5	56.5	67.8
Turdus philomelos	56	11	42	19.6	42.3	58.9
Carduelis spinus	52	11	43	38.5	49.4	63.5
Anthus trivialis	51	17	37	35.3	42.5	51.0
Phylloscopus sibilatrix[c]	45	15	39	40.0	60.0	86.7
Turdus merula	37	7	31	29.7	49.5	64.9
Columba palumbus	35	6	25	17.1	34.3	51.4
Regulus regulus	30	5	22	20.0	35.6	53.3
Muscicapa striata[c]	29	5	20	17.2	42.5	69.0
Sylvia borin[d]	26	11	22	42.3	56.4	76.9
Prunella modularis	24	4	16	16.7	38.9	58.3
Loxia sp.	24	6	24	25.0	47.2	70.8
Cuculus canorus	23	5	18	26.1	46.4	78.3
Parus major	23	3	18	21.7	34.8	43.5
Phylloscopus collybita	23	5	16	21.7	40.6	60.9
Corvus corone cornix	20	4	12	30.0	41.7	55.0
Emberiza citrinella	20	4	16	20.0	41.7	65.0
Mean	49.8	17.2	41.8	29.8	46.7	65.1

[a] Estimated by summing the highest numbers recorded within each kilometer of the transects.
[b] Estimated by comparing the results of the nine censuses in June with the maximum numbers of pairs.
[c] The first count on 14–15 May not included, as only a small part of the population had arrived.
[d] Both May counts excluded due to the late arrival of the species.

All the sources of error listed above will be accentuated in small samples, and reduced as more data are gathered. With extensive data, covering hundreds of line-transect kilometers each year, their effect might be expected to approach zero. But we have a good example which shows convincingly that, unfortunately, this is not always so. The example concerns the recent population trend of the Starling (*Sturnus vulgaris*) in Finland.

In the 1970s, Finnish field ornithologists and even farmers interested in nature noted a rapid decrease in the numbers of Starlings, which culminated in a crash during the last years of the decade. This catastrophic decline was documented by several long-term censuses of populations nesting in boxes and was reported from different parts of the country (von Haartman 1978a, 1978b; Ojanen et al. 1978; von Knorring 1978; Korpimäki 1978; Tiainen and Solonen 1979; Orell and Ojanen 1980). At the same time, the annual numbers of nestlings ringed in Finland showed a continuous steep decrease (Saurola 1978). However, when the extensive Finnish line-transect material from the years 1973 to 1977 was analyzed by Järvinen and Väisänen (1978d), no trend of decline in the Starling population was found. On the contrary, the authors concluded that the Finnish Starling population was fairly stable in the period in question, and even increased in 1977. The striking discrepancy between the two sets of data is shown by Fig. 2. If line-transect data collected from more than 2000 km and concerning one of the commonest species fail to reveal even such dramatic and well documented changes in numbers, how can this method be considered reliable when smaller quantities of data, scarcer species or lesser changes in populations are concerned?

When we remember that even the mapping method, in spite of its high effort (10 visits to the study plot), may fail to reveal marked population changes (Berthold 1976; Nilsson 1977b, 1977c), it is not surprising that the Finnish line-transect method, based on single counts, is considerably less successful.

LONG-TERM CHANGES IN AVIFAUNA

The biases involved in the method of monitoring bird population changes by means of line-transect data grow even more serious when long-term trends are concerned. In this instance

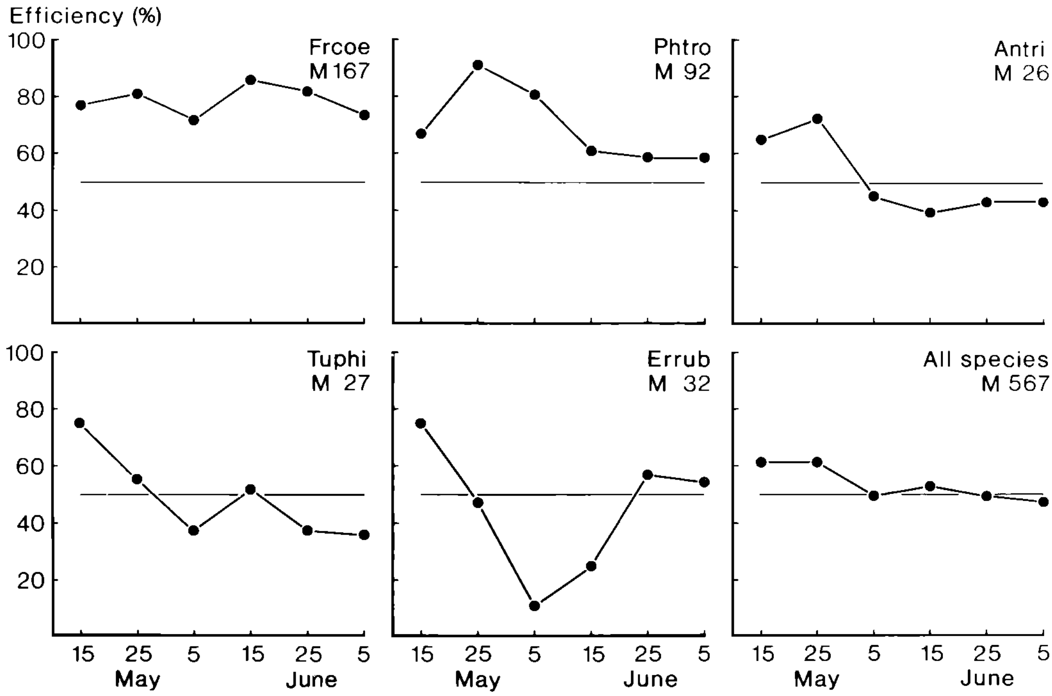

FIGURE 1. Seasonal fluctuations in the census efficiency for five selected species (*Fringilla coelebs, Phylloscopus trochilus, Anthus trivialis, Turdus philomelos, Erithacus rubecula*) and the entire bird community (excluding 12 species arriving late) in S Finland. The data are based on combined numbers of pairs of three line-transects, censused at ca. 10-day intervals from mid-May to early July. M = mean of all six censuses.

one has to compare old and current censuses, which invariably brings forth a number of new sources of error. In addition to the factors treated above, at least the following weaken still further the reliability of the results obtained.

(1) Present-day ornithologists are much more skillful and better equipped when identifying birds in the field than were their predecessors.—The tremendous advances in field ornithology are self-evident, but how much this factor has affected the line-transect censuses in different periods can only be guessed (for details, see Hildén 1979).

(2) Distant visual records and acoustic records are utilized today to a much greater extent than formerly.—Probably most ornithologists are ready to accept this statement, but only a few seem to have realized its powerful impact on field ornithology. I have considered this problem in many ways and concluded that the whole attitude to field observations has changed during recent decades (Hildén 1979). Formerly one had to see or hear a bird well and at close range before its identification was accepted, but nowadays even distant birds are assigned to a species from a hasty glimpse or faint call-note, and just as easily with the help of ears as eyes. This change in ease of identification of birds must have influenced the results of censuses, but by how much is, of course, impossible to evaluate.

(3) Individual differences between ornithologists are accentuated when the data of one early student are compared with the average of dozens of present-day census takers.—The bulk of earlier line-transect data in Finland was gathered by one single man, E. Merikallio. He was born in 1888 and thus a genuine representative of the old ornithologist generation; the line-transect material he collected at the advanced age of 53 to 68 years. It is hard to believe that Merikallio's census results from the 1940s and 1950s could be directly comparable with the current ones, compiled by mainly young, modern ornithologists in the 1970s.

(4) The working methods and the timing of censuses have somewhat changed.—The standard rules for line-transect censuses have remained roughly the same from Merikallio's time to the present, but there are some slight differences between the practices followed formerly and now; e.g., in the dates and time of day of the censuses, the speed of walking on the transects, the use of supplementary belt observa-

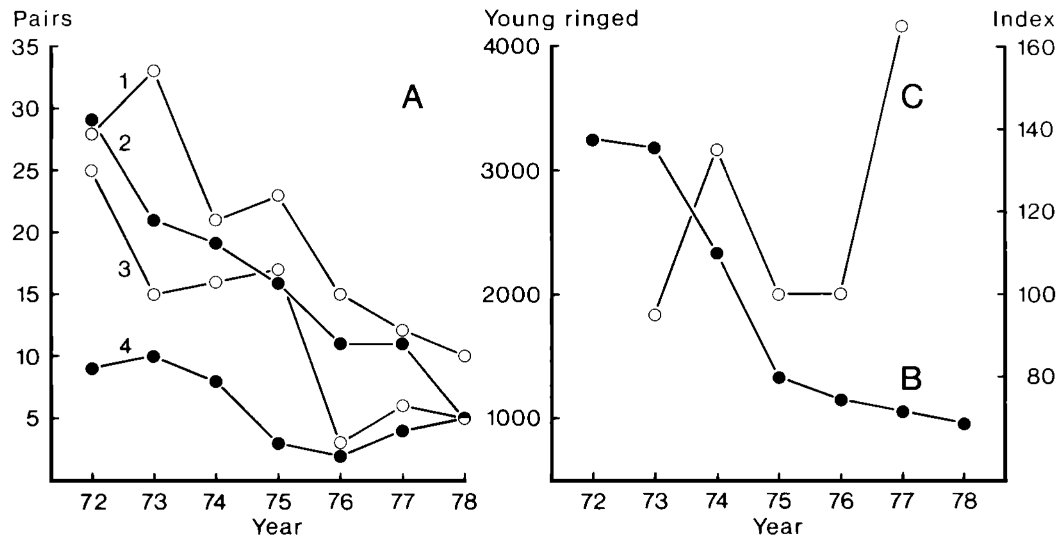

FIGURE 2. Trends in the numbers of Starlings (*Sturnus vulgaris*) in Finland in 1972–1978. A. Annual counts of pairs nesting in boxes in four areas in different parts of the country: 1 = Lammi, S Finland (Tiainen and Solonen 1979, pers. comm.), 2 = Oulu area, N Finland (Ojanen et al. 1978, Orell and Ojanen 1980), 3 = Lemsjöholm, SW Finland (von Haartman 1978a, 1978b), 4 = Salo, SW Finland (von Knorring 1978, pers. comm.). B. Annual numbers of nestlings ringed in Finland (Saurola 1978, pers. comm.). C. Annual index values of densities according to Finnish line-transect data collected from 2163 km (Järvinen and Väisänen 1978d).

tions, etc. These differences are likely to have affected the results to some extent, at least for certain species, but again their significance cannot be measured.

(5) The data for many species are sparse and thus liable to wide limits of error.—Although impressive when considered as a whole, the Finnish line-transect material is relatively small with respect to scarce species. In view of all the sources of error involved in the method, particular care is needed when conclusions are drawn from sparse data. Can a species be said to have decreased if it is represented in two samples from different years by, say, 6 and 3 observations? In my opinion, such a conclusion is not justified. But some of the long-term trends reported by Järvinen and Väisänen (1978c) for an area in southern Finland are, in fact, based on such small species.

(6) Long-term changes may be masked by annual fluctuations, as most data for the periods to be compared often are confined to 1–2 years only.—In their study of long-term changes in the Finnish avifauna, Järvinen and Väisänen had divided the line-transect material into three periods, 1936–49, 1952–63 and 1973–77. Within these periods, however, the data are not evenly distributed between the years. Thus, in the first period most data were collected during four summers between 1942 and 1947 (Merikallio 1946, 1951); i.e., in the years following the extremely severe winters at the beginning of the 1940s. Similarly, in the second period no less than 39% of all line-transects were censused in 1955 (Järvinen and Väisänen 1979a:265), which happened to be a year with an exceptionally cold spring. In the third period also, half the material is from one year, 1977 (Järvinen and Väisänen 1978d), and the whole period either overlaps or immediately follows the warmest five-year period ever recorded in Finland, 1971–75.

The populations of most small passerine birds are known to fluctuate considerably from year to year, peak densities being often 2–3 times higher than the troughs. As the Finnish line-transect censuses are so clearly concentrated in certain, often climatically exceptional years, the population indices obtained for the three periods hardly represent reliable averages of the entire periods, but rather the situations that prevailed in the main (atypical) census years. Consequently, the indices, even if real, are unlikely to show the true long-term trends in the populations of different species.

Järvinen and Väisänen have come to the general conclusion that most of the common landbirds in Finland have increased in number during the last 30 years. According to them, no less than 72.5% of the 40 most abundant south Finnish forest bird species have shown a steady increase from 1936 to 1977, 17.5% have fluctuated irregularly, and only 10% have decreased (Järvinen and Väisänen 1978b). These results have been met with a certain skepticism in Finland, as such a strong increase of the entire bird fauna, including species from a variety of different habitats, appears puzzling. To me, the key to the riddle seems clear: the "general increase" is to a considerable extent only apparent and explicable on methodological grounds. First, the average census efficiency (points 1–4 above) is likely to have improved in parallel with the general advances in field ornithology, resulting in more birds being observed on the transects now than formerly. Second (point 6), the censuses of the first two periods were confined to years following exceptionally severe winters or cold springs when many species had low population densities, whereas the opposite was true of the third period.

To conclude, I wish to make two proposals. First, single line-transect counts should be abandoned in bird census work because of their unreliability. Instead, each transect should be censused three times in different phases of the breeding season, and only the highest numbers recorded for each species should be taken into account. Second, more absolute methods of censusing based on mapping of territories, searching for nests and observing adult birds should be used whenever possible (cf. Berthold 1976).

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