Bird population monitoring: a comparison between annual breeding and migration counts in Sweden

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When establishing bird census routines aiming at long-term population size monitoring the traditional option has been to count breeding birds. The British Common Birds Census adopted a system of sample plots that were censused by the territory mapping method (Williamson & Homes 1964) and the North American Breeding Bird Survey employed a point count technique (Robbins & Van Velzen 1967).

It is natural first to turn to the breeding populations when wanting to record annual population fluctuations or long-term trends of population size. If one requires information on the breeding populations of specified regions, it is the only alternative, unless the birds are resident the year around. But breeding bird counts is not the only alternative. Counts of migrants is another option, especially if it is not necessary to know exactly from where the birds originate.

A reason to look for additional monitoring activities is that breeding bird censuses have some obvious weaknesses. It is practically difficult to establish a representative sample of census sites over a large geographical region, such as Sweden. It is also difficult, and costly, to sample all major species and habitats. Busse (1980) also stressed some methodological weaknesses. Current census methods are mainly based on the number of singing males, rather than on the actual number of present males (which, for small passerines, is impossible to ascertain by routine counts). Especially for long-lived birds such a "buffering" surplus of non-territorial and non-breeding individuals, not included in the counts, could delay the detection of a population decline. Busse also pointed out that if optimum habitats for a certain species were over-represented among the sample sites, the amplitude of the true fluctuations could be under-estimated, and vice versa for a species for which the suboptimal habitats were over-represented.

From a purely logical point of view the number of birds counted on migration would bear a close relation to the numbers recorded in the breeding areas, at least for the wholly migrant species. Spring numbers ought to reflect breeding numbers plus the non-breeding surplus (assuming negligable mortality between arrival and breeding), and autumn numbers ought to reflect these numbers plus the surviving offspring. But for a long period of time counts of migrants, in reality counts of visible migration, were considered to give a very uncertain measure of population size. Many sources of error were listed by, for example, Edelstam (1972): shifting migration routes, changes of detectability, changes in migration and observation periods and differences between observers. As a consequence Edelstam and most other interpreters of migration data have been very cautious about inferring much about population changes from counts of visible migration.

It was, however, for some species at least, clear that such migration counts did reflect true population changes: the heavy decline in the population of the Peregrine Falcon *Falco peregrinus* was a very apparent feature of the counts at Falsterbo. There was also indirect evidence showing that migration counts could be used for monitoring purposes. For example, Hjort & Lindholm (1978), using ringing figures, showed that the number of Wrens *Troglodytes troglodytes* at Ottenby correlated with the severeness of the winters in the same way as did the breeding counts. They also showed that the autumn (though not spring) numbers of Whitethroats *Sylvia communis* correlated with the rainfall in the previous year in their winter quarters. Several bird observatories, among them those at Ottenby and Falsterbo, gradually standardized their observation and trapping routines in order to remove some of the sources of error. Berthold & Schlenker (1975) and Berthold et al. (1976) also incorporated very strong habitat management routines in their MRI-programme, to remove effects of local habitat changes. Within the Polish "Operation Baltic" the use of migration data for monitoring populations, and even subpopulations assumed to pass at different localities or in different migration waves, has

been quite extensive (Busse 1976, 1980, 1986). The validity of the assumption that these figures represent true population fluctuations has, however, not been substantiated, e.g. because there are no data available on breeding numbers.

One important reason for the feeling of uncertainty about using migration data as a measure of population changes has been the lack of breeding bird counts which could be used to check the migration figures. With the organization of the Swedish Breeding Bird Census in 1969 (Svensson 1975) it has now become possible for us to compare results obtained at the bird observatories with results from the breeding areas. A first effort to do this in Sweden was made by Svensson (1978) using data for the period 1969—1975. He found that positive correlations were generally obtained for short distance migrants but not for tropical migrants. The main problem in most species was that the interannual variations of the numbers achieved through migration counts were often very large (e.g. Svensson 1985).

In this paper we will extend the comparison between breeding numbers and numbers of migrants at Falsterbo and Ottenby to cover a longer period, *namely 1970—1983.* The main scope of the study will be a comparison of methods when trying to determine the annual fluctuations.

Data and methods

We have used data of the following kinds:
A. Counts of breeding birds
1. Counts in study plots 1970—1983.
   Plots of different size (10—100 ha) have been censused using the territory mapping technique (Svensson 1975). Annual indices of population change have been calculated in the standard way (Svensson 1981; method identical with the one used in the Common Birds Census).
2. Point counts 1975—1983.
   Routes with 20 stops with counts of all birds during 5 minutes were used. An index of population size was calculated in the same way as above.
   The data for both breeding censuses refer to the southern half of Sweden.
B. Counts of migrants
1. Counts of visible migration at Falsterbo 1973—1983.
   Daily counts were made from half an hour

before sunrise until 1400 hrs, between 11 August and 20 November. All birds within range of visibility were recorded.
2. Ringing of migrants at Ottenby 1970—1983.
   Trapping was carried out in the garden surrounding the lighthouse and bird observatory, using mist nets and two permanent Heligoland-type traps. It took place between sunrise and mid-day from about 15 March until about 15 November, whenever weather permitted and there were birds in the garden. The material from Ottenby has been divided into a spring and an autumn period using 30 June/1 July as dates of division (Hjort et al. 1981).

We calculated 16 different sets of correlation coefficients as shown in Tab. 1 and Appendix 1. All correlations are straightforward Pearson correlation coefficients. No corrections were made in order to remove the effects of long term trends in the data.

We selected 41 species (Appendix 1) but all species could not be used in all 16 sets of correlations because all species did not occur or meet our requirements in all sets of data. Particularly for Falsterbo the number of species included was low because many of the most important species at this locality, for example birds of prey, are not counted either at Ottenby or in the breeding censuses. In our comparisons we therefore included only passerines and the Great Spotted Woodpecker *Dendrocopos major.*

Results

All correlation coefficients that have been calculated are given in Appendix 1, together with the critical values for two levels of significance. These correlation coefficients have been summarized in Table 1, where we also give the expected frequences and the result of a G-test between the observed and expected frequences.

It is clear that only in a few comparisons the number of significantly positive correlation coefficients deviate appreciably from what would be expected if the correlation coefficient were a random variable. The two different methods for monitoring breeding numbers show the greatest number of strong positive correlations. Three other comparisons also give more positive correlations than would be expected to appear randomly: territory

Table 1. Number of correlation coefficients at different significance levels for the 16 pairwise comparisons given in Appendix 1. Significance levels (one sided tests): * = positive correlation, p < 2.5%, x = positive, 2.5 < p < 5%, + = positive, p > 5%, — = negative. T = Territory mapping in sample plots, P = Point counts, A = Autumn figures from Ottenby, S = Spring figures from Ottenby, F = Autumn figures from Falsterbo. Each comparison is made in the temporal order given: P/S, for example, is a comparison of point counts with Ottenby in the next spring. G-test with Williams correlation.

Compared	Observed					Expected				G-test	
	*	x	+	—	Total	*	x	+	—		
T/P	7	2	9	5	23	0.6	0.6	10.4	11.5	29.0	***
T/A	1	1	14	6	22	0.5	0.5	9.9	11.0	4.6	NS
T/S	3	1	13	5	22	0.5	0.5	9.9	11.0	10.2	*
T/F	1	1	3	1	6	0.2	0.2	2.7	3.0	5.3	NS
P/A	2	4	18	9	33	0.8	0.8	14.9	16.5	11.9	**
P/S	2	0	14	13	29	0.7	0.7	13.1	14.5	4.0	NS
P/F	1	2	10	4	17	0.4	0.4	7.7	8.5	6.9	NS
A/T	2	0	12	8	22	0.5	0.5	9.9	11.0	1.9	NS
A/P	1	1	21	10	33	0.8	0.8	14.9	16.5	5.2	NS
A/S	3	0	17	9	29	0.7	0.7	13.1	14.5	4.7	NS
A/F	1	0	4	6	11	0.3	0.3	5.0	5.5	0.5	NS
S/T	4	3	6	9	22	0.5	0.5	9.9	11.0	15.8	**
S/P	1	0	18	10	29	0.7	0.7	13.1	14.5	3.3	NS
S/A	1	1	19	8	29	0.7	0.7	13.1	14.5	5.9	NS
F/T	1	1	1	2	5	0.1	0.1	2.3	2.5	5.3	NS
F/P	2	0	8	6	16	0.4	0.4	7.2	8.0	1.8	NS

mapping vs. Ottenby spring figures in the next year, point counts vs. Ottenby autumn figures, and Ottenby spring vs. territory mapping figures.

Even if most correlation coefficients do not reach significant levels, we can see from Table 1 that positive correlations are more common than negative ones. Among the 16 comparisons the average number of positive correlations is 68%.

Species accounts

A few species will be discussed in more detail below to illustrate the kinds of data we have used in our comparisons. We include the Great Spotted Woodpecker as an example of a species with an irruptive mode of migration, for which we know that migration counts cannot be used for monitoring breeding populations. The other species which we treat separately are all regular migrants.

Great Spotted Woodpecker *Dendrocopos major,* (Fig. 1). Both kinds of breeding counts agree very well. Peak numbers occurred in 1981, after a good year also in 1980. Winter numbers peaked in the winter of 1980/81 and a population crash occurred in the late summer or autumn 1981 (Svensson 1984). The breeding index for 1970—1974 is uncertain because of the small sample. Then there was

one irruption in 1975 when the population had reached a bottom level and another in 1981 when the population had reached a peak level. However, as the irruptions recorded at Ottenby may be of partly or wholly eastern origin, they cannot be used to show if irruptions may occur at any population level. But this is what could be expected, since the onset of migratory movements are determined by the combined effects of population density and food abundance. Anyhow, there is a strong correlation (r = 0.81) between the autumn and next spring figures at Ottenby, showing that the woodpeckers return towards their breeding areas.

Dunnock *Prunella modularis* and Robin *Erithacus rubecula* (Fig. 2). In these two species there is a strong correlation between the breeding counts, which both peak in 1974 and 1980. Both species winter in western and southwestern Europe and are exposed to effects of adverse winter weather, which is probably a major factor determining breeding population levels. At Ottenby there is no real correlation between spring and autumn figures for either species. Nor is there any general correlation between the species. The pronounced peaks in spring figures of the Dunnock in 1976 and 1981 have no corresponding peaks in the Robin. There is, however, a good agreement between the autumn figures
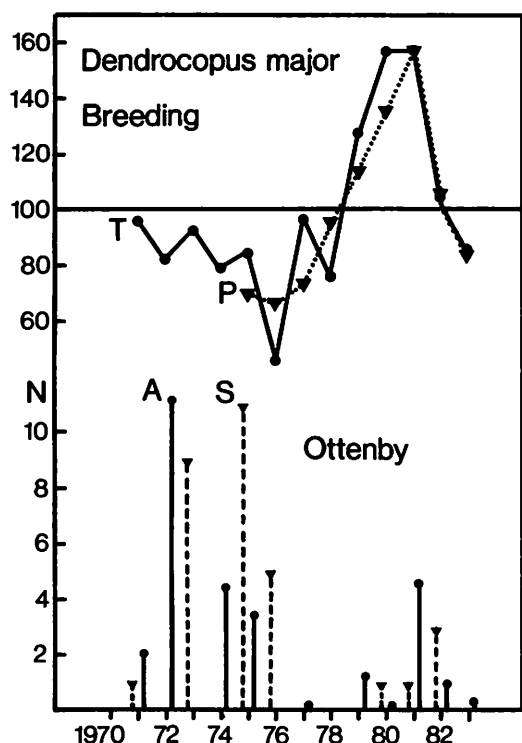
Fig. 1. Great Spotted Woodpecker *Dendrocopos major.*
T = territory mapping, P = point counts, S = spring and
A = autumn ringing figures at Ottenby. The autumn fi-
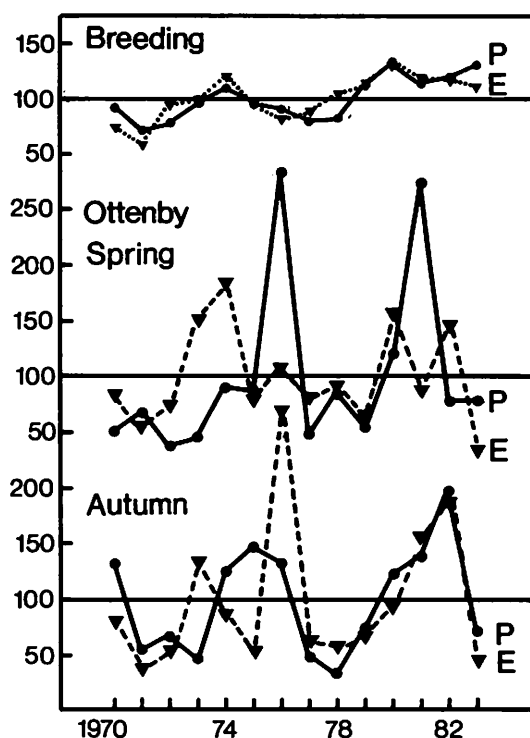gures should be multiplied by 10.

Fig. 2. Breeding indices for Dunnock *Prunella modula-
ris* (P) and *Erithacus rubecula* (E) according to territory
mapping. Below are spring and autumn ringing figures
from Ottenby.

for the two species during the latter half of the peri-
od, with peak numbers in 1982. The Robin peak in
the autumn of 1976 may be explained by an influx
of birds from the Baltic countries (Hjort & Lind-
holm 1977, Lindholm 1978). As regards the long-
term trends there is a clear similarity both between
breeding and ringing figures and between spring
and autumn trappings.

Icterine Warbler *Hippolais icterina* and Garden
Warbler *Sylvia borin* (Fig. 3). The breeding counts
indicate increasing population size, strong in the Ic-
terine Warbler, moderate in the Garden Warbler. If
we disregard the annual fluctuations we find a simi-
lar trend in the Ottenby figures for the Icterine
Warbler, both in spring and autumn. In the Garden
Warbler it is not possible to find such an agree-
ment, but the annual variations are greater and
may swamp the trend, if there is one. Both species

are night migrants with winter quarters in tropical
Africa.

Goldcrest *Regulus regulus* (Fig 4). This species
represents a group of birds characterized by partial
migration. It is generally believed that the north-
ernmost populations are migratory and the south-
ernmost mainly resident. It is also often assumed
that some populations migrate to a smaller or larg-
er extent depending on population size and amount
of food available, but little is known about this.
The figures at Ottenby from spring and autumn
correlate rather well, both when we compare figu-
res in the same year and between autumn and next
spring. There is also a reasonable agreement be-
tween the migration figures and the breeding index.
The low numbers at the beginning of the study peri-
od and in 1979 probably resulted from severe win-
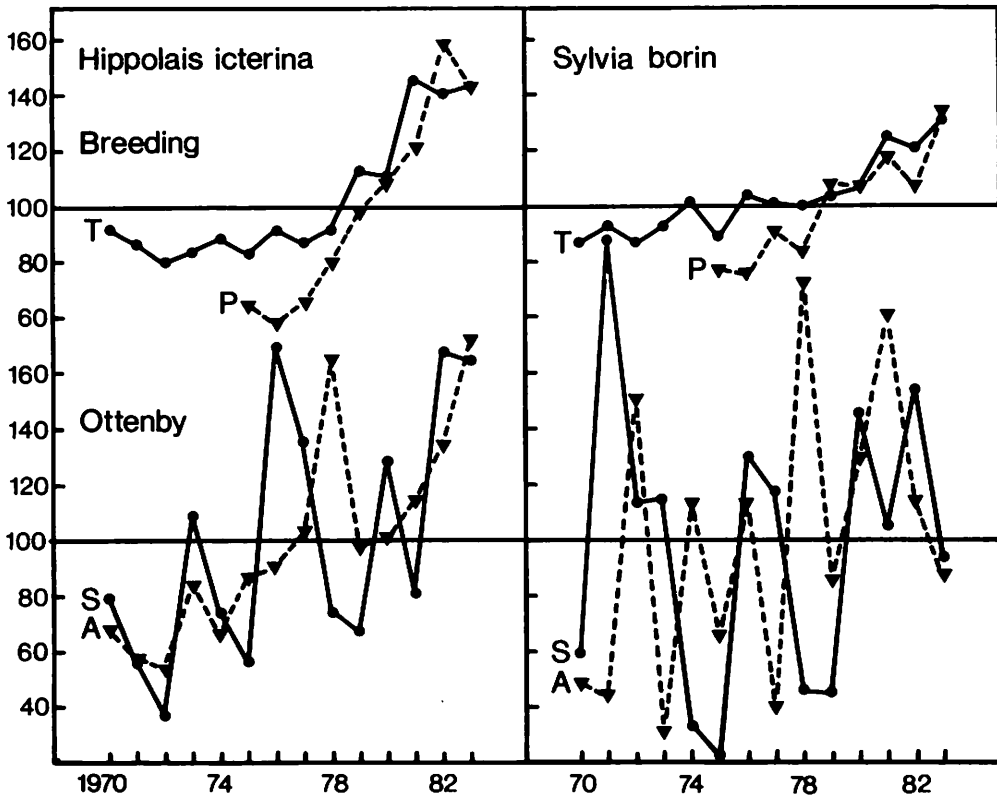ters. It is surprising, however, that the mid-winter

Fig. 3. Icterine warbler *Hippolais icterina* and Garden warbler *Sylvia borin*. T = territory mapping, P = point counts, S = spring, A = autumn.

index does not vary more than it does, in fact less than the breeding indices. The coefficient of variation for the winter index is 12% compared to 30% for the summer index and 70% for the migration counts. This can be explained if we assume that the population size of the Goldcrest is limited by the autumn resources, which then must have been rather stable during the study period (cf. Nilsson 1986). It is particularly surprising that the winter population did not decline much in 1978/79, but on the other hand the effects of this severe winter perhaps did not affect the population until in late winter, i.e. after the mid-winter count was made. In any case there were very few Goldcrests on migration both in spring and autumn of 1979. Perhaps the migration figures reflect the size of the annual surplus after an early autumn saturation of the Scandinavian forests.

Linnet *Carduelis cannabina* (Fig. 5). At Falsterbo this species shows a pattern similar to the one Roos (1984) drew attention to for six other species (*Alauda arvensis, Eremophila alpestris, Plectrophenax nivalis, Emberiza citrinella, Carduelis carduelis*, and *Carduelis flavirostris*). All species are seed-eaters and pass Falsterbo rather late in the season. The pattern for the Linnet is most similar to that of the Twite, as both started with a low figure in 1973. The autumn pattern at Ottenby is very similar to that at Falsterbo, and, excluding 1972, the spring figures also show the same pattern. The breeding index shows much less variation but, nonetheless, indicates somewhat lower figures from 1978 onwards.
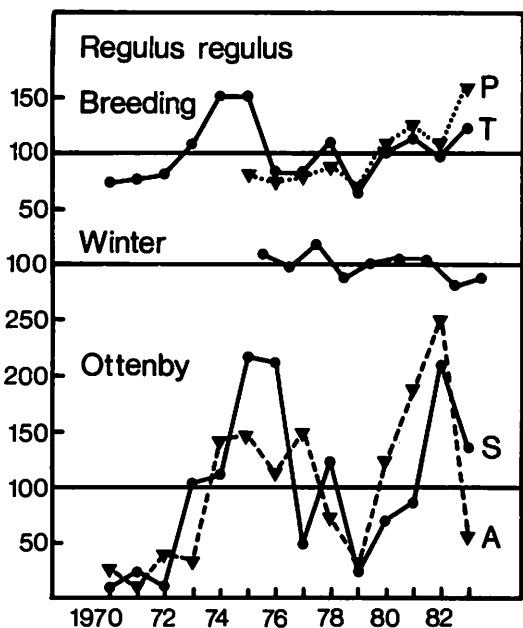
Fig. 4. Goldcrest *Regulus regulus*. T = territory mapping, P = point counts, S = spring, A = autumn.
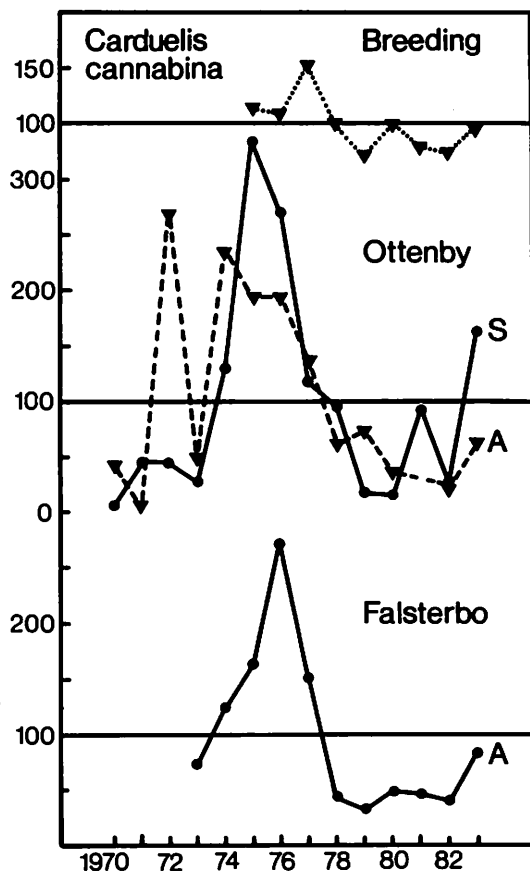

Fig. 5. Linnet *Carduelis cannabina*. The breeding index is from point counts. S = spring, A = autumn.

Discussion

The representativeness of the data

When comparing data from breeding areas with migration counts it is of course important to know if it is the same populations that are counted. Ringing recoveries provide information about recruitment areas for birds trapped at the bird observatories (Roos 1984 for Falsterbo and Liljefors et al. 1985 for Ottenby), and for both Ottenby and Falsterbo, especially for Ottenby, it is quite clear that the recruitment areas are very much larger than the area covered by the breeding bird censuses. The numbers recorded at these observatories do in fact

sample most of Fennoscandia, plus large areas east thereof.

The Robin, for example, has a southwesterly migration route. The summer recoveries of Robins ringed at Ottenby are located in the eastern part of South Sweden (14) and in Finland and the Baltic republics (19). It seems, however, that the share of eastern birds vary from year to year. In the autumn of 1976, when easterly winds were uncommonly persistent, the number of birds trapped late in the season was unusually high (Hjort & Lindholm 1977). This was explained as an effect of wind and weather conditions, bringing not only Robins but also Great tits of eastern origin to Ottenby (Lindholm 1978). Such shifts of the migration routes,

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with extreme influxes of eastern populations (Pettersson & Lindholm 1983) can be safely accounted for only if the different populations can be morphologically distinguished (Hjort & Pettersson 1985). Otherwise it will constitute a source of variation difficult to handle.

It is also important to recognize that young birds predominate among the passerines trapped at the bird observatories. The percentage is often around 90 (e.g. Pettersson 1983), i.e. higher than their true share of the autumn population (70—75%; Lack 1965). Thus the autumn trapping figures from Ottenby would seem more likely to reflect productivity than the size of the breeding population, unless productivity is about the same from year to year. Busse (1980) argued that the main factor explaining the high variability of migration counts, compared to breeding counts, is that the former include all birds (breeding, non-breeding and young birds) whereas the breeding counts include only the breeding birds (and the non-breeding territory holders). His conclusion is likely to be correct, and perhaps the breeding part of the total population may also be underrepresented at the coastal bird observatories. Perhaps the adult birds do not rest as much as the young ones, or have a stronger tendency to rest at inland localities (Stewart et al. 1974, Ralph 1981).

Another problem when interpreting migration figures is partial migration. Species like the Siskin *Carduelis spinus*, Yellowhammer *Emberiza citrinella*, and Goldcrest are typical partial migrants, who winter in considerable numbers in Sweden.

We have so far assumed that the breeding bird counts rather accurately reflect the population changes in South Sweden. In the introduction we drew attention to some sources of error, but the methods used are at least precise enough to show what happens within the territory holding (i.e. singing) part of the population within the areas sampled. This does not directly mean that the results are representative for the whole population or the whole of South Sweden. The location of study plots and point transects is arbitrary so there is considerable bias both geographically and in terms of habitat quality. However, data from the Common Birds Census in Britain show that population changes in woodland and in farmland are similar in species that occur in both habitats. From the present material we can also see that the two independent sets of breeding data often agree well. This speaks in favour of the assumption that changes in

the breeding populations are not local phenomena, but have wide geographical validity.

The variability of counts

Svensson (1978) showed that the variability of migration counts was much higher than that of breeding bird counts. We have repeated his calculations using the longer time series available now. The results are presented in Fig. 6. It can be seen that the coefficient of variation for the migration counts almost invariably falls within the range 30—100% and depends only slightly on sample size. Species considered easy to count accurately (birds of prey and doves) have a C.V. around 40%. Species which show irruptive tendencies have a C.V. considerably above 100%.

Clearly, both the easiness of making a count and the true variability of numbers affect the measured variability. It seems possible to conclude that the migration counts carry an inherent variability around 50%. The question is now, how much of this variability depends on true variation of numbers and how much depends upon external factors, such as weather. If the main factor is the number of birds then the variation must be explained by high variation in the production of young, since the breeding bird counts have much lower variation (Fig. 6B). Especially the counts with the territory mapping method show low variation, usually less than 25% even for small sample size, and the variability rapidly declines towards 10% with a larger sample.

The large geographical areas sampled by Ottenby and Falsterbo must have much larger internal variations in factors like weather and food availability during the breeding season than the much smaller area sampled by the breeding bird censuses. These local variations may to some extent counterbalance each other, and should thus depress the interannual variations of the whole sample. If that is the case, then the fact that the interannual variations of the migration counts are as large as they are clearly indicates dependability on some external factors during migration.

Alerstam (1978) made a detailed study on how weather affected migration, but confined his analysis to within-year variation. He concluded that different weather factors, taken together, efficiently explain a large share of the day to day variability of migration. One must assume that differences in the number of suitable or unsuitable days also af-
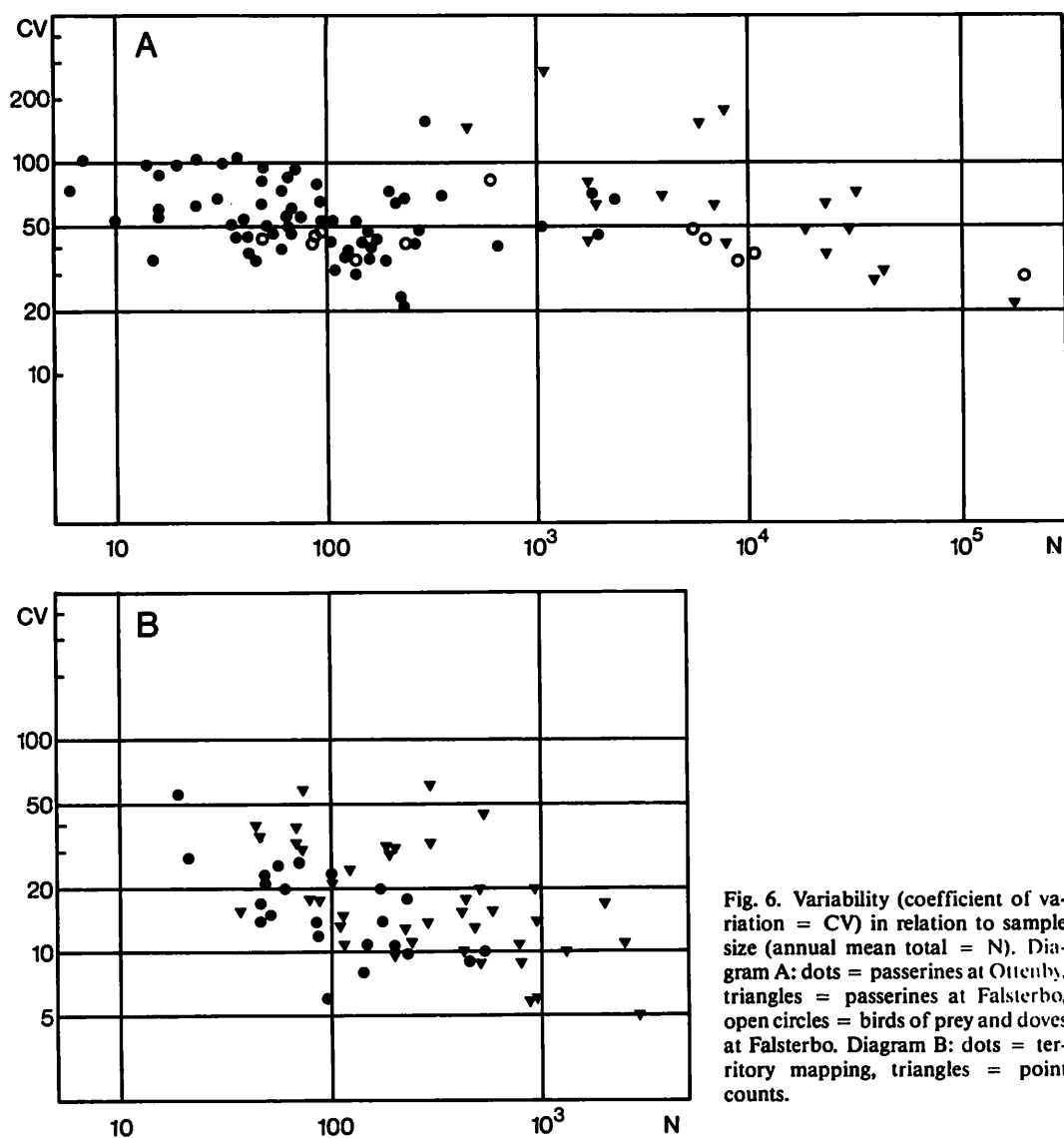
Fig. 6. Variability (coefficient of variation = CV) in relation to sample size (annual mean total = N). Diagram A: dots = passerines at Ottenby, triangles = passerines at Falsterbo, open circles = birds of prey and doves at Falsterbo. Diagram B: dots = territory mapping, triangles = point counts.

fect the annual totals. That this is the case for at least some species at Ottenby, was shown by Pettersson (1985), who got good correlations between September—October numbers of Robins and Goldcrests and the frequency of easterly winds. This does not only illustrate that migration counts are to a large extent influenced by weather, but further emphasizes the fact that bird populations monitored at Ottenby come from a very much larger region than southern Sweden.

Conclusions

The fact that we obtained a greater number of positive than negative correlation coefficients indicates that there is some general agreement between migration counts at Ottenby and Falsterbo and the number of breeding birds in southern Sweden. In such species, in which the measured changes of breeding population size have been rather strong, we obtain clear trends also in the migration figures.

We therefore believe that the long-term trends will be accurately demonstrated by both the breeding bird censuses and the migration counts, as long as the migration "routes" and weather conditions do not show any long-term shifts. For individual years, however, these migration counts, including populations from much larger areas and influenced by weather factors, must not be supposed to monitor the breeding populations of southern Sweden. Rather they illustrate the overall variation as seen in a larger Baltic context.

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Appendix 1. Correlation coefficients for the sixteen pairwise comparisons given in Tab. 1. The first two decimals are given. T = Territory mapping plots, P = Point counts, A = Ottenby autumn, S = Ottenby spring, F = Falsterbo autumn. At the bottom lines the critical levels for r are given, two-sided test. The first three decimals are given.

Species	T/P	T/A	T/S	T/F	P/A	P/S	P/F	A/T	A/P	A/S	A/F	S/T	S/P	S/A	F/T	F/P
Dend majo	91	—	—	—	—	—	—	—	—	81	—	—	—	—	—	—
Alau arve	—	—	—	—	—	—	60	—	—	—	—	—	—	—	—	87
Hiru rust	—	—	—	—	—	—	—47	—	—	—	—	—	—	—	—	—23
Deli urbi	—	—	—	—	—	—	15	—	—	—	—	—	—	—	—	—23
Anth triv	—32	—52	29	77	69	81	—61	—31	53	21	—36	—20	32	23	79	80
Mota flav	—	—	—	—	—	—	08	—	—	—	—	—	—	—	—	42
Mota alba	—	—	—	—	57	27	10	—	42	57	14	—	49	46	—	14
Trog trog	67	36	42	—	46	—26	—	11	—07	—19	—	61	38	44	—	—
Prun modu	73	46	50	—	08	—25	—	11	00	30	—	—30	07	42	—	—
Erit rube	80	11	16	—	04	—04	—	04	—56	—11	—	48	51	45	—	—
Lusc lusc	44	23	63	—	79	47	—	—18	42	28	—	—59	—34	—00	—	—
Phoe phoe	—	—	—	—	16	—30	—	—	23	18	—	—	71	—16	—	—
Turd meru	—20	—03	—03	—	59	—29	—	—33	—38	31	—	23	—64	—03	—	—
Turd phil	21	28	—11	—	—16	45	—	10	02	—29	—	24	49	31	—	—
Turd ilia	—	—	—	—	—03	—02	42	—	53	—03	—34	—	—14	06	—	16
Hipp icte	93	64	57	—	54	35	—	67	51	30	—	47	34	52	—	—
Sylv curr	—	—	—	—	12	89	—	—	—10	34	—	—	—23	—01	—	—
Sylv comm	28	24	24	—	—15	14	—	40	62	24	—	—31	—32	15	—	—
Sylv bori	87	36	—04	—	08	38	—	40	46	—04	—	16	26	—15	—	—
Sylv atri	—46	—34	—04	—	62	08	—	30	58	04	—	—24	21	24	—	—
Phyl sibi	55	19	28	—	—28	—24	—	—10	—31	+00	—	79	64	40	—	—
Phyl troc	33	13	11	—	11	14	—	56	47	69	—	—04	49	06	—	—
Regu regu	43	40	76	—	06	46	—	24	53	66	—	56	03	59	—	—
Musc stri	—12	—44	—41	—	—08	26	—	48	20	26	—	—24	—37	19	—	—
Fice hypo	61	21	08	—	08	—05	—	—43	—30	14	—	—05	25	38	—	—
Paru coer	12	40	40	28	—36	—30	25	09	—18	15	03	57	—38	20	—18	38
Paru majo	65	08	07	53	41	—28	30	34	06	—31	—14	—18	—23	09	—	—
Cert fami	—	—	—	—	—24	—	—	—	46	—	—	—	—	—	—	—
Lani coll	—	—	—	—	01	10	—	—	08	20	—	—	41	—16	—	—
Corv mone	—	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—28
Corv coro	—	—	—	—	—	—	19	—	—	—	—	—	—	—	—	35
Stur vulg	09	—17	45	—67	—06	06	73	—08	—34	—19	—04	30	42	—09	—69	39
Frin coel	30	33	01	—	—31	—86	—	46	13	44	—	00	14	22	—	—
Frin mont	—	—	—	—	27	—	—	—	—17	—	—	—	—	—	—	—
Card chlo	—	—	—	—	48	—32	—92	—	58	—33	—03	—	—57	—38	—	—16
Card spin	—	—	—	—	01	—	05	—	—10	—	29	·	·	·	·	06
Card cann	—	—	—	—	64	30	63	—	77	46	78	—	47	50	—	86
Pyrr pyrr	—	—	—	—	60	—	—	—	10	—	64	—	—	—	—	—
Embe citr	—72	04	28	45	02	02	—41	17	51	—02	—05	11	10	22	60	—41
Embe scho	82	—02	32	16	25	—03	52	—20	55	16	12	47	18	19	08	16
Crit. 10%	582	457	476	521	582	621	582	476	582	476	521	457	582	457	549	582
Crit. 5%	666	532	553	602	666	707	666	553	666	553	602	532	666	532	632	666