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The effect of observer variability on bird census results obtained by a territory mapping technique

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This study was carried out to determine whether experienced ornitohologists could replace each other in a census programme using the territory mapping technique. We studied the variation between different observers carrying out a 10-visit mapping census in the same plot and in the same period of time. The test was repeated in two consecutive seasons in a plot with about 50 territorial males. The coefficient of variation for the total counts of territories was 14 and 10% respectively in the two seasons. The variation between the observers decreased with increasing sample size in good agreement with the theoretical expectation. Consequently, it could be concluded that census data obtained from different observers were comparable, at least so long as the process of species map evaluation did not introduce any additional variation.

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Introduction

When applying territory mapping techniques in bird census work, viz. techniques like those used by Enemar (1959), and also in most censuses within the so called Audubon programme in North America (Hall 1964, Van Velzen 1972), in the Common Birds Census on the British Isles (Williamson and Homes 1964), and in the Swedish Breeding Bird Census (Svensson 1974a, b), there are principally three factors that may cause different final results when the same bird community or bird population is censused by several observers. The three sources of variation are: (1) varying detectability of birds, causing different results even when the observers are equally efficient, (2) varying efficiency among observers, causing different results even when the detectability of the birds is the same, and (3) variation in the ways observers interprete and evaluate species maps.

The field effort, i.e. the effort producing the species maps, can be standardised as to part of season, time of day, duration of visits, etc., and also, at least to some extent, as to weather conditions. It is therefore possible to reduce the variation caused by varying detectability inherent among the birds themselves. It is more difficult to standardise the perceptability of the observers since this depends on a number of partly uncontrollable and partly unknown factors such as visual and audial capa-

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city, alertness, behaviour in the plot, previous ornithological training, and previous experience of census work. These latter sources of variation will of course be most important in extensive census programmes involving large numbers of voluntary bird-watchers, less in small scale studies with experienced and trained personnel.

Standardisation of the evaluation of the species maps can also be made, for example along the lines given by the International Bird Census Committee (Anon. 1969) involving among other things a specified minimum number of records for a cluster of registrations to be counted as representing a territory or a pair.

Differences in the evaluation of species maps as a source of variation are best studied by comparing the results that different persons get when evaluating identical species maps (Svensson 1974c). Such tests will, however, represent a somewhat artificial situation, since normally it is either the same person that carries out both the field work and the evaluation, or a central office with trained personnel that performs map evaluation in a standardised way.

As a monitoring device and also as a device for comparing bird densities in different plots there are no obvious reasons to believe that the mapping methods should not work satisfactorily as long as all the plots to be compared – in time or in space – were censused and evaluated by the same person, provided the capacity of this person did not change in time or was different in different habitats. But as soon as a census programme involves more than a few sample plots it becomes imperative to be able to distribute the work among several field workers and also to change personnel between seasons in the same plot. Therefore it also becomes necessary to evaluate the possible effect on the census result that such a change of personnel may introduce. This paper presents the results of such an investigation.

Methods

Design of the experiment

When performing our experiment we used one of our permanent study plots at Ammarnäs, Swedish Lapland, viz. the plot A4 (Enemar et al. 1965). This is a strip plot 100 m broad and 1170 m long running through the sub-alpine birch woods on the south-facing slopes of the mountain Kaissats, about 8 km west of Ammarnäs. The experiment took place in 1966 and 1967. The persons taking part were the three authors (both years) and Sven Åke Hanson (in 1966 only). All participants were trained field ornithologists. They all had extensive and comparable experience of the mapping technique.

Since one of our aims with the test was to study the degree of inter-observer variability under conditions similar to those that had prevailed during the previous seasons within our longterm census programme in different habitats at Ammarnäs, we avoided the enforce-

Tab. 1. Date of visits and total number of field hours. V = one visit.

Year and observer	June 8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	Field hours
1966																									
AE						V		V	V			VV	VV						VV	V					14 h 00 min
BS							VV		VV				V	VV					V		V		V		16 h 40 min
SS							VV		VV				V					V	V		VV		V		16 h 00 min
SH								V			VV			VV			V	V				VV		V	18 h 15 min
1967																									
AE			V		V	V	V		V					V	V		V		V		V				16 h 00 min
BS					VV			V					V	V		V		V	V		V	V			17 h 40 min
SS	V			V		V			V		V		V		V		V	V	V						20 h 40 min

Tab. 2. The distribution of visits over different hours of the day.

Year and observer		Before 07 hours	07–11 hours	11–15 hours	After 15 hours
1966	AE	3	5	2	0
	BS	3	3	2	2
	SS	3	2	5	0
	SH	2	6	2	0
1967	AE	1	8	1	0
	BS	0	5	5	0
	SS	0	5	5	0

ment of a stricter standardisation of our field behaviour than had earlier been adopted as a routine. The observers agreed on the following principles before the start of the experiment. Each observer was to carry out his census in a way as similar as possible to the conventions adopted during the previous seasons, and, furthermore, to avoid unduly influence from or on his co-workers.

The species maps were evaluated according to the recommendations given later by the International Bird Census Committee (Anon. 1969). This means, among other things, that a territory holder was required to be registered at a minimum of three of the ten visits to be included in the count. The evaluation work was carried out and the result agreed upon by all three authors.

The field effort

Data on the distribution of the visits over the season and over the hours of the day as well as the total number of field hours have been summarised in Tabs 1 and 2. It can be seen that a number of double visits – two visits the same day – were carried out in 1966, a schedule deliberately abandoned in 1967.

The census period was 15, 17, 17, and 17 d for the four persons in 1966 and 19, 18, and 19 d in 1967. The average date ranged from 20 to 23 June in 1966 and from 18 to 21 June in 1967. The total number of field hours varied somewhat between the participants. In 1967 the participants spent about two hours (about eleven minutes per visit) more in the plot than in 1966.

The distribution of the visits over the hours of the day (Tab. 2) was very similar for the different observers. In 1966 there was some concentration to the late morning hours, but visits were made also in the early morning and in the early afternoon. In 1967 there were few visits in the early morning.

During the field work all species contacted within the

Tab. 3. Number of territories obtained by the different observers in 1966 and 1967 separately and in both years together. For some species two figures are given. The first shows the number of certain territories (minimum number) and the second figure the additional number of uncertain territories. Both together give the maximum number. In all calculations in this report the mean of these two figures has been used.

Species	Observer 1966				Observer 1967			Observer 66+67		
	AE	BS	SS	SH	AE	BS	SS	AE	BS	SS
Phylloscopus trochilus	15+3	14+2	14+2	12	18+3	18+1	17+2	33+6	32+3	31+4
Fringilla montifringilla	7+1	8+1	9	5+1	7	6	6+1	14+1	14+1	15+1
Emberiza schoeniclus	4+1	4	6	3+1	4	3	2	8+1	7	8
Prunella modularis	2	3	4	2	4	4+1	1+1	6	7+1	5+1
Anthus trivialis	2	4+1	4	2+1	2	3	3	4	7+1	7
Carduelis flammea	2	2	2	0	4	3+1	2+1	6	5+1	4+1
Ficedula hypoleuca	2	2	2+1	2	3	2	3+2	5	4	5+3
Luscinia suecica	1	1+1	2+1	2	4	1+1	3	5	2+2	5+1
Sylvia borin	3	3+1	3	3	0	0	0	3	3+1	3
Phoenicurus phoenicurus	1	1	2	1	2	2	1	3	3	3
Fringilla coelebs	1+1	2	1	1	0	0	0	1+1	2	1
Saxicola rubetra	1	1	1	1	0	0	0	1	1	1
Parus montanus	0	0	0	0+1	1	0	0	1	0	0
Muscicapa striata	0	0	0	1	0	0	0	0	0	0
Total	41+6	45+6	50+4	35+4	49+3	42+4	38+7	90+9	87+10	88+11
Maximum total	47	51	54	39	52	46	45	99	97	99

Tab. 4. Number of contacts obtained by the different observers in 1966 and 1967. ( ) = did not produce a permanent territory.

Species	Observer 1966 AE	BS	SS	SH	Observer 1967 AE	BS	SS	Observer 66+67 AE	BS	SS
Phylloscopus trochilus	105	105	102	90	121	133	115	226	238	217
Fringilla montifringilla	37	49	54	32	31	47	30	68	96	84
Emberiza schoeniclus	21	18	26	20	17	17	13	38	35	39
Prunella modularis	13	13	24	12	23	25	15	36	38	39
Anthus trivialis	10	23	23	10	12	18	18	22	41	41
Carduelis flammea	7	11	12	(3)	19	27	15	26	38	27
Ficedula hypoleuca	9	13	17	16	18	27	28	27	40	45
Luscinia suecica	2	7	10	10	21	15	18	23	22	28
Sylvia borin	14	11	17	15	(1)	(3)	0	15	14	17
Phoenicurus phoenicurus	10	4	9	4	10	9	5	20	13	14
Fringilla coelebs	6	9	4	5	0	(2)	0	6	11	4
Saxicola rubetra	3	3	3	5	(1)	0	0	4	3	3
Parus montanus	(2)	(4)	(1)	6	4	(2)	(3)	6	6	4
Muscicapa striata	(2)	(1)	(3)	3	(1)	(4)	(1)	3	5	4
Parus major	(2)	(4)	(1)	0	0	0	0	2	4	1
Pyrrhula pyrrhula	0	0	0	0	0	0	(2)	0	0	2
Anthus pratensis	0	0	0	0	0	0	(2)	0	0	2
Total	243	275	306	231	279	329	265	522	604	571

plot were registered. In this paper we have, however, restricted the discussion to the small passerines. A few non-passerines, for example *Lagopus lagopus,* were registered, and also a number of thrushes (*Turdus pilaris, T. musicus,* and *T. philomelos*) were breeding in the plot. These species were not counted with the mapping technique, but with nest search, and they have therefore been excluded here.

Finally it should be stressed that throughout this paper we do not consider the accuracy of the population size estimates, i.e. their relation to the true number of birds, but only the variability of the estimates.

Results and discussion

About fifty territories of the species included in this study were mapped each year within the plot (Tab. 3). They represented fourteen species. *Phylloscopus trochilus* dominated with more than one third of the territories. The next most common species, *Fringilla montifringilla,* was less than half as common. Most other species occurred in quite low numbers. Three species belonging to the category of this study were observed but did not provide enough registrations to be counted as territorial in the plot: *Parus major, Pyrrhula pyrrhula* and *Anthus pratensis.* Two of the other species (*Parus montanus* and *Muscicapa striata*) were evaluated as having permanent territories in only one case each. *Fringilla coelebs, Sylvia borin* and *Saxicola rubetra* were stationary in the plot in 1966 only.

In some cases two figures are given in Tab. 3. This is because we were not able to separate some neighbouring clusters of registrations unambiguously. In all calculations in this report we have used the average between the two estimates.

Tab. 5. Analysis of possible differences between the observers in the number of contacts. The Willow Warbler *Phylloscopus trochilus,* all other species, and all species were analysed separately using analysis of variance on each group.

	Range	Mean	S.D. n = 10	F[1]	Grand mean	S.D.
Phylloscopus trochilus 1966 (4 observers)						
AE	7–14	10.5	2.84			
BS	4–16	10.5	4.09	0.63	10.1	2.80
SS	8–13	10.2	1.69			
SH	6–12	9.0	2.16			
All species except *Phylloscopus trochilus* 1966 (4 observers)						
AE	7–19	13.8	3.88			
BS	3–28	17.0	6.68	3.22	16.3	5.86
SS	14–37	20.4	7.32			
SH	11–17	14.1	2.02			
All species 1966 (4 observers)						
AE	15–31	24.3	4.06			
BS	7–44	27.5	10.30	2.46	26.4	7.18
SS	23–47	30.6	7.29			
SH	18–28	23.1	3.11			
Phylloscopus trochilus 1967 (3 observers)						
AE	9–16	12.1	2.33			
BS	8–17	13.3	2.95	1.39	12.3	2.49
SS	9–15	11.5	2.01			
All species except *Phylloscopus trochilus* 1967 (3 observers)						
AE	3–21	15.8	5.98	1.97	16.8	5.73
BS	11–28	19.6	5.19			
SS	7–22	15.0	5.44			
All species 1967 (3 observers)						
AE	12–34	27.9	7.26			
BS	25–44	32.9	6.03	2.75	29.1	6.79
SS	17–34	26.5	5.87			

1. Critical value of F (0.05-level, two-tailed) was for 1966 3.51, for 1967 4.25.

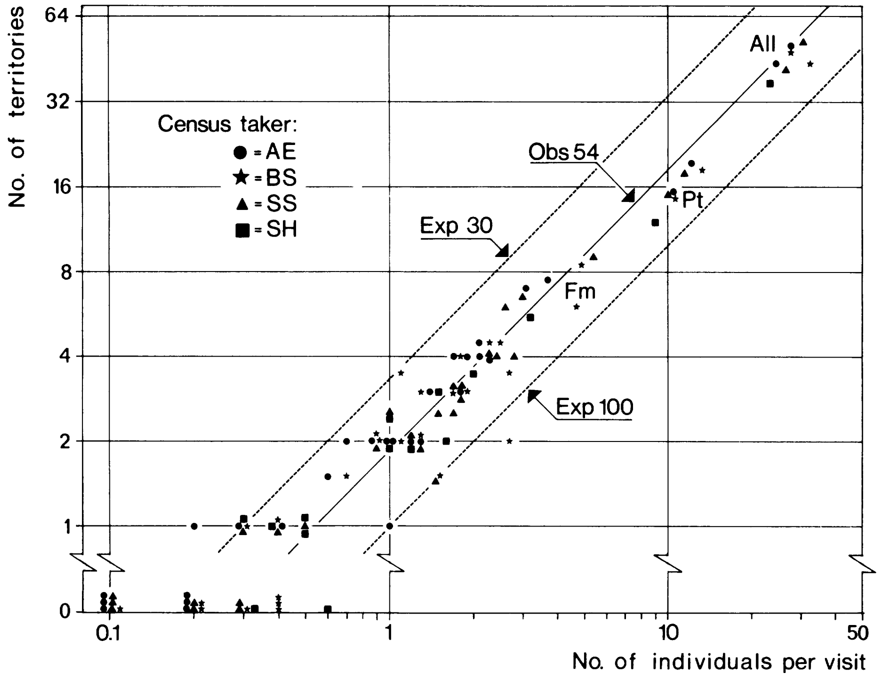

Fig. 1. The relation between number of individuals observed per visit and the number of territories evaluated. The data are given separately for each year, each observer, each species, and the total community. The key to the observers is given in the figure. Key to year is not given. Key to species is given only for the whole community (All), *Phylloscopus trochilus* (Pt) and *Fringilla montifringilla* (Fm). The diagonal lines indicate different levels of census efficiency: Exp 30 is where the dots would have fallen if there were three contacts in each territory (the minimum requirement for counting a cluster as a territory). Exp 100 shows where the dots would have fallen if the observers were 100% efficient, i.e. observed all individuals at all ten visits. The line Obs 54 shows the average efficiency actually obtained (the efficiency for each species and year was calculated first and then the average was taken over all species and years).

The number of territories evaluated is largely a function of the average number of contacts registered during the field surveys (Fig. 1). The number of contacts is obviously an alternative estimate that could replace the number of territories as an index of population density. The number of contacts is given in Tab. 4 for all species including those three that did not register as stationary.

Differences between the observers in obtaining the contacts

The number of registered contacts provides the most primary set of data for a test of observer field variability. The cluster evaluation of the species maps must necessarily introduce new factors (which may increase or decrease variability). By analysis of variance we compared the observers using the number of contacts registered during the separate visits for (a) *Phylloscopus trochilus*, (b) all other species, and (c) the whole community. The results are shown in Tab. 5. The F-values did not in any of the tests exceed the critical value of the 95% level of significance.

We also compared the number of species for which each of two observers obtained the highest count. The expectation being of course that each of them scored highest in about the same number of species. This test revealed that in none of the nine possible comparisons was there a significant difference either in the counts of territories or in the counts of contacts.

The coefficient of variation for the total number of contacts was similar in both years: 13 and 12% respectively, and also for the most common species, *Phylloscopus trochilus:* about 7%.

The change between years

One of the most important questions is whether the change in the population size from one year to the next is registered equally well by two observers. For the three observers that counted the birds in both years we investigated whether they all registered the same direction of the changes.

The data for this analysis are collected in Tab. 6. We can see that among the thirteen species listed the observers agreed as to direction of change in nine. One of the observers disagreed with the other two in four species. We can also see that in none of the observers were the direction of change measured differently by using the number of contacts and the number of territories.

Using also the quantitative information of Tab. 6 we calculated the correlation coefficients for the change.

Tab. 6. The change in number of territories and number of contacts from 1966 to 1967.

Species	Observer AE		Observer BS		Observer SS	
	Territories	Contacts	Territories	Contacts	Territories	Contacts
P. trochilus	+3	+16	+3.5	+28	+3	+13
F. montifringilla	−0.5	− 6	−2.5	− 2	−2.5	−24
E. schoeniclus	−0.5	− 4	−1	− 1	−4	−13
P. modularis	+2	+10	+1.5	+12	−2.5	− 9
A. trivialis	0	+ 2	−1.5	− 5	−1	− 5
C. flammea	+2	+12	+1.5	+16	+0.5	+ 3
F. hypoleuca	+1	+ 9	0	+14	+1.5	+11
L. suecica	+3	+19	0	+ 8	+0.5	+ 8
S. borin	−3	−13	−3.5	− 8	−3	−17
P. phoenicurus	+1	0	+1	+ 5	−1	− 4
F. coelebs	−1.5	− 6	−2	− 7	−1	− 4
S. rubetra	−1	− 2	−1	− 3	−1	− 3
P. montanus	+1	+ 2	0	− 2	0	+ 2

Tab. 7. Comparison between the coefficient of variation (c.v.) for the number of territories and the number of contacts. Different combinations of species and years are used. The F-ratio was calculated as the ratio between the squared coefficients of variation taking the lowest as denominator. A significant difference is indicated with an asterisk. Critical values are: F (4;4) = 9.60, F (3;3) = 15.44, both for a significance level of 0.05 (two-tailed).

Species group and year	N	Number of territories mean	Number of territories c.v.	Mean no. of contacts mean	Mean no. of contacts c.v.	F-ratio	Lowest c.v.
All species 1966	4	45.25	14.14	26.37	12.79	1.22	T[1]
All species 1967	3	45.33	10.25	29.10	11.56	1.27	C[2]
All species 66+67	3	93.33	1.35	56.57	7.29	29.16*	T
Pt 1966	4	14.62	12.91	10.05	7.11	3.30	C
Pt 1967	3	18.67	4.09	12.30	7.45	3.32	T
Pt 66+67	3	34.17	4.70	22.70	4.64	1.03	C
All excl. Pt 66	4	30.62	17.65	16.32	18.84	1.14	T
All excl. Pt 67	3	26.68	14.56	16.80	14.63	1.01	T
All excl. Pt 66+67	3	59.17	1.95	33.87	11.05	32.11*	T
Fm 1966	4	7.62	20.30	4.30	23.79	1.37	T
Fm 1967	3	6.50	7.69	3.60	26.49	11.87	T
Fm 66+67	3	14.83	3.89	8.27	16.99	19.08	T
Es+Pm 66+67	3	14.17	4.07	7.50	3.54	1.32	C
Fh+At+Ls 66+67	3	15.83	17.39	9.63	22.61	1.69	T
Cf+Sb+Pp+Fc+Sr+Pam	3	14.33	11.21	8.50	9.63	1.34	C
Fm+Es 66+67	3	22.67	4.59	12.00	10.64	5.37	T
Pm+Fh+At+Cf 66+67	3	23.00	7.84	14.00	18.03	5.29	T
Fm+Es+Pm 66+67	3	29.00	0.00	15.77	8.89	–	T
All but Fm, Es, Pm, Pt	3	30.17	3.83	18.10	12.99	11.50	T

1. Count of territories.
2. Count of contacts.

The coefficients for number of territories were: 0.88*** (AD/BS), 0.65** (AE/SS), 0.65** (BS/SS), and for number of contacts: 0.83*** (AE/BS), 0.78*** (AE/SS), 0.66** (BS/SS).

We conclude that the observers registered the changes from one year to the next equally well both when using contacts and territories.

Which is the most useful estimator?

When counting the number of birds in a plot using a territory mapping technique at least three different estimators can be considered: (1) number of evaluated territories, (2) mean number of contacts per visit (or total number of contacts during all visits), and (3) maximum number of contacts during a visit.

It is evident that the estimator with the lowest variability is to be preferred when different population size estimates should be compared. This estimator is not necessarily the best estimator for other purposes, for example in estimating the true population size.

We have compared the coefficient of variation (c.v.) for the number of territories and the number of contacts for several species groupings (in order to increase sample size) in Tab. 7 (cf. also Fig. 3). The differences between the coefficients have been tested using the ratio between the squared coefficents of variation (the

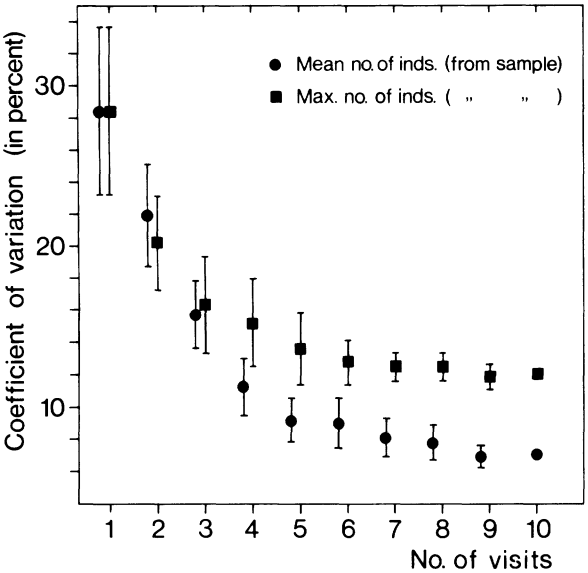

Fig. 2. Change in the coefficient of variation with increasing number of visits for *Phylloscopus trochilus* in 1966 (four observers). For each number of visits the c.v. was calculated from a sample of ten random combinations of visits. This was done for a) the mean number of individuals (circles), and b) the maximum number of individuals (squares). The vertical bars represent the 95% confidence limits.

highest value as denominator) and comparing these values against the corresponding critical F-values. Excluding the grouping Fm + Es + Pm which by necessity becomes significant for any value of c.v. except zero, we see that in only two groupings we find a significant value for the F-ratio.

The maximum number of contacts is not a likely measure to be chosen when a low c.v. is aimed at, but it has been used several times in population density estimates since it can normally be expected to be a better estimate of the true population size than the mean number of contacts. Therefore we have compared these two measures in Fig. 2. We chose the *P. trochilus* data from 1966. As we could expect the mean is better than the maximum value. We can also see that the mean can be expected to be better than the maximum already after about half the present number of visits. Our further analysis will therefore be restricted to a comparison between mean number of contacts and number of territories.

The relation between sample size and variability

In order to study the relation between sample size and variability we have used the data of Tabs 3 and 4 to construct Fig. 3. Logarithmic scales were used in order to obtain linearity. The expected relation of c.v. (for the number of contacts) to the number of contacts (if x is binomially distributed) is

$$\text{c.v.} = \frac{1}{x}\sqrt{\frac{x(1-p)}{A}}$$

where x is the number of contacts (= np), n being the population size, p the census efficiency (assumed to be constant in all species and observers) and A the number of observers. The individual efficiencies were 0.55–0.66 when we simply divided the number of contacts by the number of evaluated territories. When dividing with the maximum number of territories registered by any of the observers (assuming this to be a better measure of the true number of territories) the p:s became 0.44–0.59. The grand mean using the first method was 0.61. When first calculating the specific efficiencies (pooling the observers) and then averaging over all species we got a p of 0.54. We have, in Fig. 3, because of the ambiguity, indicated a zone instead of a line to show the expectation, using the outer limits of p = 0.54; A = 3 and p = 0.61; A = 4, respectively.

It is clear that the observed regression agrees well with the expectation but the slope is slightly smaller. The expression above can be rewritten: log c.v. = a log x + log b (or in exponential form: c.v. = b x^a) where a equals $-1/2$ and b equals $(1-p)/A$. The regression parameter estimates for each year were b = 35.5 and b = 31.4, and a = 0.405 and a = 0.530 (1966 and 1967 respectively).

With a constant number of observers the b-value is only dependent upon p and it will decrease with increasing efficiency. But increasing p also increases x, and there will be a decrease in x^a. The final result on the c.v. is different in different p-regions. For already high p:s it is not very rewarding in terms of decreased variability to work for increasing the efficiency further, but it is very rewarding to increase n, sample size (= plot area). On the other hand, for low efficiencies, it can be rewarding to try to increase census efficiency instead, since increasing the sample plot may involve unproportionally much additional work. This is because n and x are linearily related to sample size while p is not except when p is small; then p is approximately proportional to time spent in the area (time being the most probable variable for affecting efficiency).

We have analysed p, x and c.v. at some length using the number of contacts in order to understand the general behaviour that they show. We can apply this knowledge to the number of territories of Fig. 3 for which the expected relation between c.v. and sample size was not computed. The observed regression for the values of both years in Fig. 3 is c.v. = 55.6 $x^{-0.707}$. For the separate years the following values were obtained:

1966: b = 50.3	a = −0.609
1967: b = 75.2	a = −0.939

It can be seen that the slope is steeper for the number of territories indicating a more rapid decrease of variability. There is, however, a complicated relationship because many species with different census efficiencies are involved. Fig. 1 shows that the efficiency was different for different species (for example lower in the rarest species and higher in the commonest) and this may

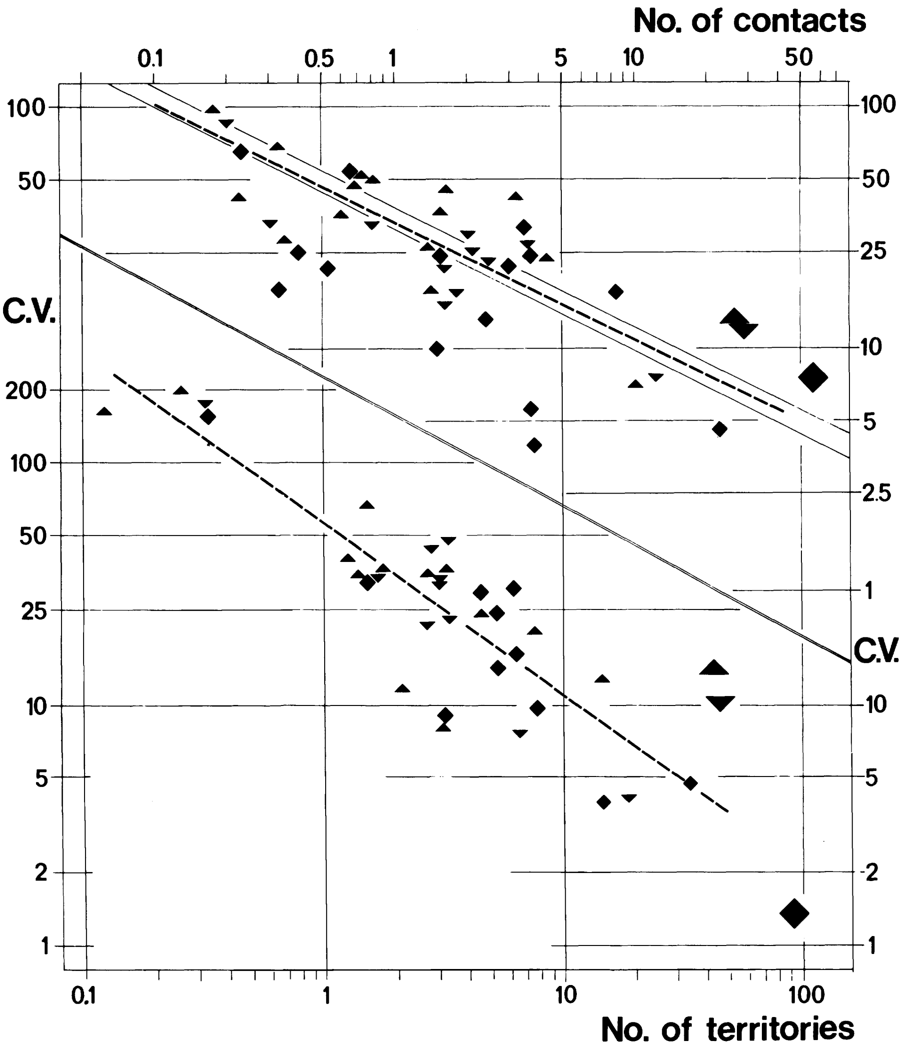

Fig. 3. The relation between the coefficient of variation (c.v.) and the number of contacts (upper part of figure) and the number of territories (lower part of figure). Entries are given for every species and year and for every species both years pooled (▲ = 1966, ▼ = 1967, ◆ = 1966 + 1967). The totals are also given (big marks). The regression lines (the heavy dotted lines) are calculated on the basis of all entries in the figure. In the upper part of the figure the expectation zone is indicated with two lines.

affect the difference between c.v.-values obtained for territories and contacts.

Generality of our results

Very few studies on observer variability have been carried out although this problem is central for determining the accuracy of a comparison between census results from different areas and different time periods. Of course, the problem is most significant in small, specialised studies with few census workers. In largescale programs with several tens or hundreds of observers one can expect no or only an insignificant bias introduced by observer variability, unless there is some general 'drift' in average efficiency.

Since our work at Ammarnäs involves a small number of census plots and since our main aim is to monitor population changes over many years it is imperative that the average efficiency remains constant. We had to know if we could replace each other in the plots and if we could introduce new co-workers without seriously affecting the quality of our counts. And this problem must be quite common in bird population studies, since it is appreciated and discussed in almost any study of quantitative ornithology.

We must therefore ask to what extent the conclusions that we can draw from our experiment can be generalised. The basic provision for a generalisation is, of course, that we count the birds in a way (with the same average efficiency and with the same distribution of efficiences among the species) that is representative for an average census taker. The paucity of information from simultaneous counts make our effort in this direction a rather difficult one.

We have been able to find only five studies where several observers have been counting the same bird community (but then we have excluded some experiments on other birds than small passerines and experiments from outside the breeding season).

Two of the five studies involve single simultaneous walks by several observers through a census plot. Enemar (1962) used six participants and Hogstad (1967) used four. The relation between number of contacts and the coefficient of variation was as follows (within parenthesis the expected relation for $p = 0.5$):

Enemar's experiment:	c.v. = $67.9\ x^{-0.58}$ ($70.7\ x^{-0.5}$)
Hogstad's experiment:	c.v. = $53.2\ x^{-0.64}$ ($70.7\ x^{-0.5}$)
Present study, 1966:	c.v. = $35.5\ x^{-0.41}$ ($35.4\ x^{-0.5}$)
Present study, 1967:	c.v. = $31.4\ x^{-0.53}$ ($40.8\ x^{-0.5}$)

There is a fairly good agreement with the expectation under the reasonable assumption that the visit efficiency is, on the average about 50%.

The third experiment is that of Snow (1965). He used four plots and each plot was censused in the standard way (7–10 visits) by two observers in each. We cannot make a full comparison with our data because Snow provided data only for the eleven commonest species. The following relations between number of territories and c.v. was obtained using the data from all four plots pooled: c.v. = $38.9\ x^{-0.213}$. The correlation coefficient was low (0.22) and not significantly different from zero ($t = 1.32$, $df = 35$). Thus there was no measurable decrease in the variability in the more abundant species. This is in itself surprising and against expectation, but in the results we find the explanation. There are some quite remarkable differences between some of the observers in precisely the commonest species, e.g. in *Alauda arvensis* (19 and 8 territories in one plot and 13 and 7 in another plot), in *Parus caeruleus* (14 and 3 territories), in *Emberiza citrinella* (14 and 27), and in *Erithacus rubecula* (23 and 11). It cannot be judged whether differences in evaluation could be partly responsible (such differences may occasionally be considerable, see Svensson 1974c) since the statement on p. 288 does not make it clear whether the evaluation was made by one or several persons.

The fourth study is that reported by Jensen (1971–1972). He reported results obtained for 13 species censused by four observers in one 10-visit survey by three and in two 10-visit surveys by one. The relation between c.v. and number of territories was: c.v. = $88.3\ x^{-0.62}$. The rate of decrease in the c.v. is quite similar to ours in 1966 but different from that of 1967. The c.v. of Jensen is higher. This is to be expected because the visit periods in Jensen's experiment were not timed to coincide for the different observers. In fact the period of the visits did not overlap at all for some of the participants, and the periods were partly very short (11, 12, 16, 18 and 18 d). A more equal timing would certainly have reduced Jensens c.v. values to the same level as we obtained at Ammarnäs.

The fifth study is a comparison between two observers, both carrying out a full mapping census (9 and 13 visits) of the same 6.3 ha plot (Chessex and Ribaut 1966). Both arrived at quite similar population size estimates. The total number of territories was estimated to 95 and 99, and for the commonest species the observers obtained the following estimates: 25 and 27 in *Turdus merula,* 13 and 13 in *Fringilla coelebs,* and 24 and 23 in *Carduelis chloris.*

In spite of the rather unexpected result obtained in Snow's experiment we feel that we have no support in assuming that the participants in our experiment should differ appreciably from an average experienced ornithologist performing a territory mapping census. And this also means that we have no reason to believe that the conclusions arrived at in this paper should not, at least in their general outline, also be generally applicable: provided that the evaluation of the species maps is standardized experienced ornithologists can replace each other in a census scheme without violating the comparability of the results.

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