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RELIABILITY OF THE LINE SURVEY METHOD IN BIRD CENSUS, WITH REFERENCE TO REED BUNTING AND SEDGE WARBLER

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Material and methods

Surprisingly few data on the reliability of census methods exist (e.g., PALMGREN 1930, NORDBERG 1947, ENEMAR 1959, SNOW 1965, HOGSTAD 1967) although they are of prime importance in choosing a particular method.

This study was undertaken to establish to what degree of accuracy the line survey methods can cover local populations of the Reed Bunting (*Emberiza schoeniclus*) and the Sedge Warbler (*Acrocephalus schoenobaenus*). The present data collected in summer 1968 by line surveys conducted at Pori, on Välisanta island (61°32'N, 21°44'E) situated at the mouth of Kokemäki River.

This island measures about 25 hectares in area, and is covered by willow thickets of 1—2 m in height (the dominating species being *Salix phylicifolia*). Meadows make several hectares of the island's area (predominating plant species are *Carex aquatilis, Comarum palustre, Equisetum fluviatile,* etc.), and about one hectare consists of reeds. The middle part of Välisanta island grows birches about 10 m tall, and the southern end of the island is covered by alder and willow thickets of some 5 m in height.

The line surveys were conducted as described by MERIKALLIO (1946). The width of the main belt was 25+25 m and the track was about 1100 m long. The survey was taken 12 times the track being the same every time; the track followed a path through the island. The individual birds or pairs encountered within the main belt and the so-called auditory belt were recorded (Table 1). In addition, single specimens or pairs of Reed Buntings and Sedge Warblers were marked on a map according to the mapping method of ENEMAR (1959) (Figs. 1 and 2).

Since 1966 I have been studying the Reed Bunting population on the island; over 90 % of the Reed Buntings present were annually colour marked. During the line surveys in summer 1968, all 37 Reed Bunting males carried colour rings and only two of the females were not ringed. In 1968 Sedge Warblers were individually colour ringed mostly in the south of the island (within the area between H and M in Figs. 1 and 2). In order to be able to compare the results of my

TABLE 1. The passerine birds (excluding Corvidae) encountered during the line surveys. A = main belt, B = auditory belt. The numbers of singing males are shown in brackets.

No. of survey *Takseerauksen n:o*	1.		2.		3.		4.		5.
Date *Pvm.*	9.5.		20.5.		29.5.		1.6.		5.6.
Time *Klo*	05.40		06.00		08.05		06.50		05.15
	A	B	A	B	A	B	A	B	A
Parus major	—	—	—	—	—	—	—	—	—
Turdus pilaris	—	—	—	1	1	2	4	—	2
T. musicus	—	1(1)	—	—	—	—	—	—	—
Saxicola rubetra	1(1)	—	—	—	1	—	1	—	—
Acrocephalus scirpaceus	—	—	—	—	—	—	—	—	—
A. schoenobaenus	1(1)	4(4)	11(11)	8(8)	13(12)	3(3)	12(9)	6(6)	9(6)
Sylvia borin	—	—	—	—	1(1)	1(1)	1(1)	4(4)	1(1)
S. communis	—	—	1(1)	1(1)	4(3)	1(1)	3(1)	1(1)	1
Anthus pratensis	2	—	2	—	1	—	1	—	1
Motacilla flava	3	—	—	—	1	—	2	—	—
Phylloscopus trochilus	9(9)	38(38)	4(4)	12(10)	3(2)	6(6)	4(3)	9(9)	6(5)
P. sibilatrix	—	—	—	1(1)	—	—	—	—	—
Carpodacus erythrinus	—	—	—	—	—	1(1)	3(2)	3(3)	1(1)
Fringilla coelebs	—	2	—	—	1	—	1(1)	2(2)	1(1)
Emberiza schoeniclus	9(2)	5(2)	4(2)	2(1)	11(7)	2(2)	10(7)	2(2)	6(2)

survey with those obtained by the common line survey method, each track was traversed every time as if for the first time. Thus I did not check the nests found earlier, and did not use my earlier data to decide if one or two pairs of Buntings were present at a given site. Of course I did not either identify the birds by their colour rings.

Results

1. *Line survey method*

The results of all line surveys are depicted in Table 1. The exact reliability of the data can be determined only for the Reed Bunting. A determination of the reliability is difficult even in a population whose members are marked individually, because the actual number of males in the main belt is not an unambiguous matter. The territories of Reed Bunting males, though rather diffuse, are generally larger than the width (50 m) of the main belt, the territories of several males thus being only partly covered by the main belt. The following calculations are based on those males whose permanent singing sites lie within the main belt at the beginning of the egg-laying period. On these criteria, regarded satisfactory by MERIKALLIO (1946), 13 Reed Bunting males were observed in the center of the main belt and 6 on the sides. When half of the latter number is taken into account, the total number of males residing in the main belt is 16.

Another way of determining pair numbers is to count the nests within the main belt. Since only some Reed Bunting females breed twice a year, the only possible primary criterion is the number of first broods in the main belt. The first broods of all males singing in the main belt have been found and 12 of them occured in the main belt; the female (a yearling) of one pair did not lay at all and one male remained single. The

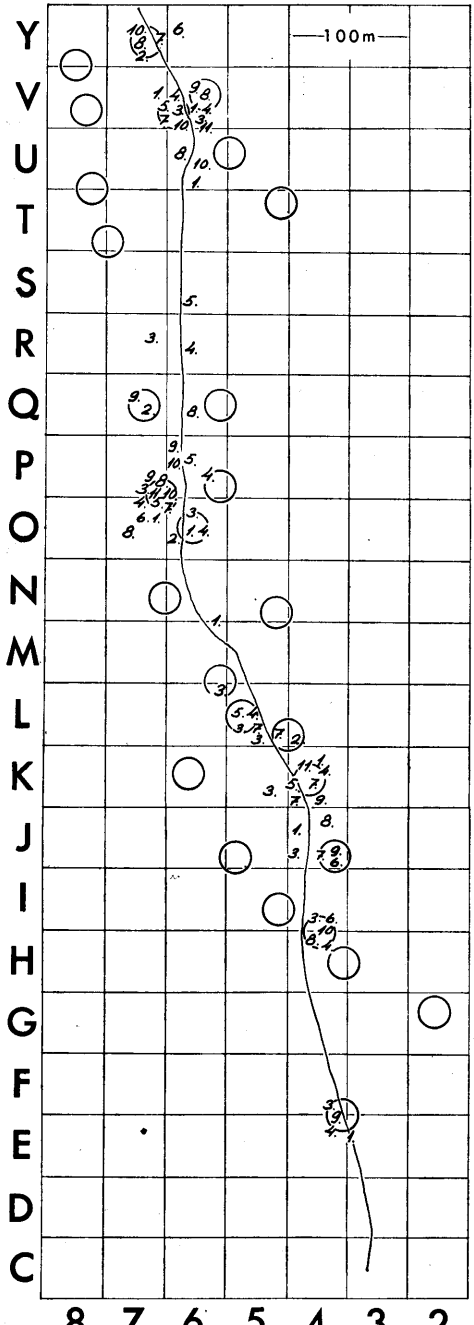
TAULUKKO 1. *Linjatakseerauksissa todetut varpuslinnut (ei varislintuja). A = pääsarka, B = kuulosarka. Laulavien koiraiden määrä suluissa.*

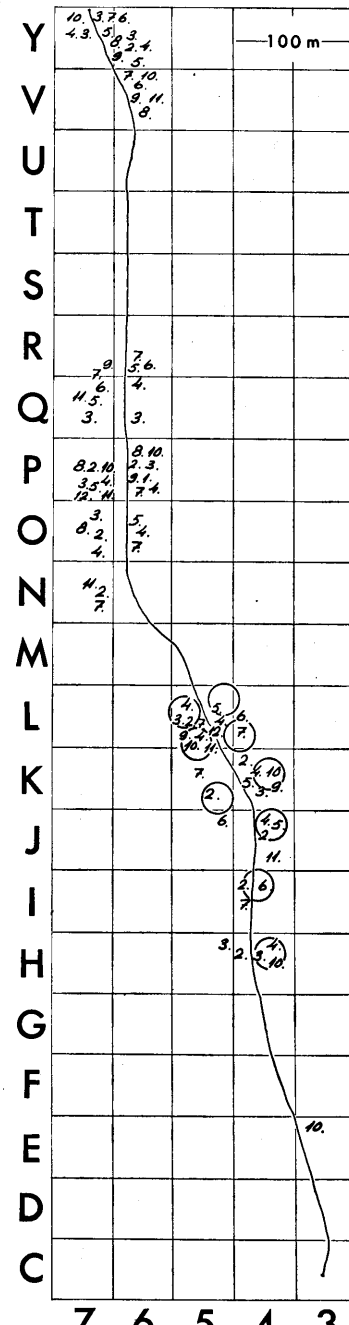
7.		8.		9.		10.		11.		12.	
13.6.		13.6.		13.6.		15.6.		15.6.		15.6.	
04.20		06.20		08.05		18.30		20.30		22.05	
B	A	B	A	B	A	B	A	B	A	B	A	B
1(1)	—	—	—	—	—	—	—	—	—	—	—	—
2	3	—	2	1	2	2	2	2	3	—	2	1
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
2(2)	—	2(2)	—	2(2)	—	—	—	1(1)	—	3(3)	—	2(2)
5(5)	11(7)	3(3)	7(5)	3(3)	6(5)	2(2)	8(4)	2(2)	5(4)	1(1)	3(3)	1(1)
7(7)	3(3)	3(3)	—	3(3)	—	2(2)	—	2(2)	—	2(2)	—	—
2(2)	2(2)	3(3)	2(2)	1(1)	—	—	—	1(1)	—	4(4)	—	—
1	1	—	1	1	1	1	2	—	1	—	2	—
1	1	1	2	—	1	—	1	—	—	—	—	—
5(5)	10(7)	9(9)	6(6)	6(6)	6(4)	9(9)	7(7)	15(15)	—	5(5)	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
2(2)	3(1)	2(2)	1(1)	2(2)	—	3(3)	1(1)	1(1)	1(1)	3(3)	—	2(2)
—	2(2)	1(1)	—	1(1)	—	—	—	—	1(1)	1(1)	—	—
3(3)	8(4)	2(1)	8(3)	1(1)	7(2)	2(2)	5(3)	2(2)	3(3)	—	—	—

nests of two pairs were outside the main belt, but on the other hand, there was a breeding pair in the main belt whose male had its singing site about 80 m away from the survey track. In many cases the singing sites of males were situated in the same bushes throughout the summer, while the nests built by one female during the same summer, were on an average 61±10 m apart (n=28) (HAUKIOJA 1968); hence the singing sites of Reed Bunting males within a given area indicate the pair numbers throughout the breeding season at least as accurately as the number of nests.

The numbers of pairs or single Reed Buntings in the main belt varied from 0 to 11 in line surveys (Table 1); the mean value was 6.4±0.9. If the pair count was based on singing males only, the mean number of Reed Buntings in the main belt would be 3.3±0.6 per each line survey conducted. The former value is 40 % and the latter 20 % of the actual number of males in the main belt. Even a fewer number of the Reed Bunting males has been recorded by the line survey method in the auditory belt, only 1.8±0.4 birds per line on an average. Of them, 1.5 were singing males, easily observed even at a distance. In addition to the 16 pairs in the main belt 12 more Reed Bunting males occurred in the auditory belt (which is 100+100 m in width); thus only a fraction of the birds in the auditory belt were covered by the line survey. Within an auditory belt 200+200 m wide there were 4 additional breeding Reed Bunting pairs at Välisanta, some of which could have been observed under favourable conditions from the survey line.

The exact number of Sedge Warblers in the main belt is not known, as only few birds were colour ringed. The following data on the reliability of the line survey are based on the study in the southern part of Välisanta (the area H-M in Figs. 1—2), where ¾ of the males were colour ringed. This part of





FIGS. 1—2. Reed Buntings (left) and Sedge Warblers (right) discovered in the main belt during the line surveys. The numbers show the number of the line survey during which the bird

the main belt was inhabited by 8—9 Sedge Warbler pairs, of which 2.8±0.6 individuals or pairs, that is about ⅓ of the actual total, was encountered in the main belt during line surveys. Sedge Warblers were observed in all 93 times on the main belt, of which 74 (about 80 %) were singing males. The corresponding percentage was 50 for the Reed Bunting, which shows that a Sedge Warbler that is not singing is more difficult to observe than a non-singing Reed Bunting, perhaps the former also sings more.

2. *Mapping method*

Figs. 1 and 2 depict the sites where the Reed Bunting and Sedge Warbler pairs or single individuals were observed during the surveys marked according to the method of ENEMAR (1959). On Fig. 1 the territories of some 12 Reed Bunting males and on Fig. 2 the territories of some 17 Sedge Warbler males can be found, but the determination of most territories is rather difficult. Later on I shall discuss the factors which affect the visibility of a particular Reed Bunting or Sedge Warbler pair.

3. *Breeding bird fauna*

Only a few surveys of passerine birds of bush growths have been conducted in Finland (e.g., FRITZÉN & TENOVUO 1957). On the other hand, passerine birds have been included in many studies covering water fowl (e.g., LINKOLA 1959).

The following list presents all bird species breeding at Välisanta in 1968. The exact numbers of the scarce species are known, and I have anyway walked within the area to the extent that most estimates of pair numbers are close to the actual value. The pair numbers of the most common species are based on estimates of how much more common or scarcer they are than the Reed Bunting.

Anas platyrhynchos. 2 nests found.
Aythya ferina. 1 nest found.
Porzana porzana. 1 pair.
Fulica atra. 2 pairs.
Vanellus vanellus. 1 pair.
Capella gallinago. Some 10 pairs.
Scolopax rusticola. 1 pair.
Numenius arquata. 3 pairs.
Columba palumbus. 3 pairs.
Corvus corone. 1 pair.
Pica pica. 2 pairs.
Parus major. 2 pairs in bird boxes in the yards of summer houses in the south of the island.
P. caeruleus. 1—2 pairs as above.
Turdus pilaris. 10—12 pairs.
T. musicus. 3 pairs.
Saxicola rubetra. 4 pairs.
Luscinia luscinia. A singing male a couple of days in early June; in 1966 and 1967 3 breeding pairs.
Acrocephalus scirpaceus. 3 pairs; none in 1966 and 1967.
A. schoenobaenus. About 40 pairs, the estimate is rather exact.
Locustella fluviatilis. One probably breeding pair in 1967 and 1968.
Sylvia borin. Clearly scarcer than the Reed Bunting; a rough estimate 20 pairs.
S. communis. 25—30 pairs.
Phylloscopus trochilus. The most abundant bird species at Välisanta; a rough estimate 70 pairs.

was encountered in the place concerned. Circles indicate the most permanent singing sites of males (for Reed Buntings within 100 m each side of the survey line, for Sedge Warblers in the southern part (area H-M) of the main belt).

KUVAT 1—2. *Linjatakseerauksissa pääsaralla havaittujen pajusirkkujen (vasemmalla) ja ruokokerttusten (oikealla) löytöpaikat. Numerot ilmaisevat, millä takseerauskerralla lintu on ko. paikassa tavattu. Ympyrät osoittavat koiraiden vakituisimmat laulupaikat (pajusirkulla 100 m:n sisällä takseerauslinjan molemmin puolin, ruokokerttusella pääsaran eteläosassa, alueella H-M).*

Anthus pratensis. Some 7 pairs.

Motacilla flava. Some 5 pairs.

Sturnus vulgaris. 5 pairs in bird boxes around summer houses.

Carpodacus erythrinus. A little scarcer than the Reed Bunting; a rather exact estimate 30 pairs.

Fringilla coelebs. About 10 pairs.

Emberiza schoeniclus. 37 males; one female disappeared quite soon after arrival.

The total number of breeding pairs on the island is about 310—320 pairs, or about 1300 pairs/km^2. Some 300 of the breeding pairs are passerines counted in the line surveys (Table 1). Using the highest line survey values obtained, the number of pairs within an area 4.5 times of the main belt (= the area of Välisanta) would be 272. This is about 72 % of the real value, and still too high as my survey track crossed the places of highest bird densities on the island.

Factors affecting the reliability of the census data

The factors affecting the results of a single survey have been discussed by, for instance, PALMGREN (1930), ENEMAR (1959), and HOGSTAD (1967).

The factors that generally are considered to distort the results of a survey have played only a small role in this survey. The weather was rather calm every time. I am familiar with the terrain and my rate of speed was rather slow, about 1 km/h, regarded suitable by ENEMAR (1959). All surveys were performed during either the morning or evening hours. In addition, I am familiar with the Reed Bunting as a species, thus being able to find them at least in the same proportion as most bird surveyors. Furthermore, I know this species in the field well enough to be able to distinguish young and old individuals; a faulty inclusion of young birds in the survey would result in too high values.

In the following I shall discuss what effect the breeding cycle may have on the reliability of the results, which, in my opinion, has not received an adequate coverage in literature, and analyse to what extent the fact that the birds were individually colour marked helped in obtaining the results.

There are only a few references in the literature (KENDEIGH 1944, ENEMAR & SJÖSTRAND 1967) to a particular *phase of the breeding cycle* affecting the efficiency of line surveys. On the other hand, the date of the survey is generally considered important. The date of the survey is usually only determined at that phase of the breeding cycle when most birds can be observed in the field with least difficulty. The changes in the numbers of males of a local population, which are referred to by ENEMAR (1959) as other factors determining the survey date, are so small in the Reed Bunting (HAUKIOJA 1968) that they are masked by other sources of error.

Because some 50 % of the observations on Reed Buntings and some 80 % of those on Sedge Warblers were made on singing males, it is clear that the accuracy of a survey is dependent of the changes in the singing intensity of males in the various phases of their breeding cycle.

Males of both Reed Bunting and Sedge Warbler are singing intensively until the arrival of females, after which they are silent for a time. A Reed Bunting male may refrain from singing for a few days immediately after pair formation and does not sing intensively again untill before laying and then less than before pairing. Singing is generally interrupted after hatching of the young but it starts again when the young attain the ability to fly. The surveys of summer 1968 do not give a true picture of the changes in the singing rhytm and thus the visibility of the males during the breeding cycle, due to unsuccesful breeding

this year. All but two pairs in the main belt failed to raise their first brood. The males could be detected more easily, because of their singing, until hatching of the replacement brood.

The survey dates recommended by LINKOLA (1959) for the Reed Bunting is 20th May—1st July. In southern and middle Finland this period occurs at the end of incubation and during feeding of the young and laying of the second brood, and some of the males are then rather difficult to observe in the field. The best time for carrying out surveys is in my opinion immediately before the arrival of females, that is in mid-April, when the males sing intensively during the morning hours. Surveying can be carried out without much difficulty at this time, but after the arrival of the first females the number of males easily detected in the field decreases rapidly. It is true that the earliest females arrive prior to the last males, but the resulting error is relatively small.

The survey dates recommended by LINKOLA (1959) for the Sedge Warbler is 20th June—10th July. Since the males and females arrive less apart in time than the Reed Buntings, the surveys carried out before the arrival of the females may not result in quite reliable data.

A particular phase of the breeding cycle also affects the value of dominance obtained for bird species, if the calculations are based on a single or a few successive surveys. The pair numbers obtained for the Sedge Warbler and the Reed Warbler (*Acrocephalus scirpaceus*) at Välisanta in summer 1968 may serve as an example. To determine the numbers of these species in a single survey, a date when both species have arrived must be selected. I carried out such line surveys on the 13th and 15th of June, altogether 7 times (Table 1). The highest number for the Sedge Warbler was 14 pairs or individuals during any single survey (this occured in a survey begun at 4.20 a.m.), while the maximum number of Reed Warblers was 3 singing males (in a survey begun at 20.30 p.m.). These results indicate that Reed Warblers numbered 1/4—1/5 of the Sedge Warblers. Actually there were some 40 pairs of Sedge Warblers and 3 pairs of Reed Warblers; since the survey was carried out after the Reed Warblers had arrived, most of the Sedge Warblers were already paired and had refrained from singing or at least their singing intensity was diminished. Hence the probability of detecting them in the field was lowered. On the other hand, the Reed Warbler males, not yet paired after arrival, sing intensively and can be easily observed by a surveyor.

Single males can easily be detected in the field because of this particular phase in their breeding cycle; they are ready to breed and hence sing intensively. A single Reed Bunting male is depicted in Fig. 1, between the squares 0—7 and P—7.

Individual differences. The probability of detecting different individuals in the Reed Bunting population studied by me varies even under similar conditions. Some males for instance sing intensively, while some others may be rather quiet a long time already before the arrival of the females. Individual differences and perhaps age influence this variation in the birds; such sources of error may be quite impossible to account for in line surveys.

Wandering individuals outside their territories may cause erraneous results in bird censuses. Once, (13th June) a male not belonging to the breeding population of Välisanta came to the main belt and was included in Table 1. Several times I came across males that did not belong to the breeding birds of the main belt. Such males do not sing, and the use of singing males as a criterion of pair numbers is well founded but not recommended for other reasons.

No *changes of territories* in the Reed Bunting population occured during the period of censuses, in May and June, but I observed a move of 400 m as late as mid-June by a male Sedge Warbler which already had a permanent singing site. Such moves of course lower the reliability of the mapping method.

Discussion

The Reed Bunting has earlier proved to be a difficult species to count in the field (ENEMAR & SJÖSTRAND 1967, WILLIAMSON 1967), but it is surprising that the Sedge Warbler, which is by SNOW (1965) considered as an 'easy' species in this respect, proved more difficult to detect.

In my opinion, it is important to carry out surveys on individually marked populations of species other than those covered here. Several extensive studies are in progress on colour-marked populations, providing exact material for comparisons. According to the present study, the mapping method in the determination of the total population is not exact at least for the species dealt with here.

According to ENEMAR & SJÖSTRAND (1967), the line survey method is not suitable for determining pair numbers only for calculating the dominance. My own study reveals that large sources of error, due to particular phases of the breeding cycle, may be involved in estimating the dominance, thus caution is warranted in calculations based on a few runs only of the line survey.

The criterion for a pair should in my opinion be any potentially breeding passerine bird or pair and not only (singing) males. The values so obtained have proved to be too low rather than too high so there is no danger of overestimation.

For instance, in Finland a new treatment of the large material obtained by MERIKALLIO (1946) would give good results, if the reliability of the line survey could first be determined for each species. It is apparent, anyway, that the pair estimates arrived at by MERIKALLIO (1958) remain below actual numbers due to shortcomings in the line survey method.

Summary

This article deals with line surveys conducted at Pori, at the mouth of Kokemäki River, in summer 1968; they were aimed at assessing the percentage of a local population of Sedge Warblers and Reed Buntings that can be covered by the line survey method. The Reed Buntings and some Sedge Warblers were individually colour marked and under a daily surveillance, and hence the actual pair numbers were known.

The results of the line surveys (always the same track) are depicted in Table 1. The actual number of Reed Buntings in the main belt was 16 males, of which one was single, and there were 8—9 Sedge Warbler pairs in the southern part of the main belt (shown in the Figs. 1—2 between the letters H and M). In the line survey, an average of 40 % of local Reed Buntings in the main belt (the percentage was 20 if only singing males were counted) and about ⅓ of the Sedge Warblers could be covered by this method. Not even with the mapping method could the territories of all Sedge Warbler and Reed Bunting males be localized (Figs. 1 and 2). The total number of birds within the area studied was 310—320 pairs, which makes some 1300 pairs/km².

Special attention was paid to how the breeding cycle was affect the efficiency of the line survey. Since the Reed Bunting males sing little if at all right after pairing and early in the nestling phase, and since 50 % of the Reed Bunting observations concerned singing males, the particular phase of the breeding cycle clearly affects the results of the survey.

It is no idea to carry out calculations of dominance that are based on a single or a few survey runs, if the species compared are in different phases of their breeding cycle.

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Selostus: **Linjatakseerausmenetelmän luotettavuudesta pajusirkun ja ruokokerttusen takseeraamisessa.**

Kirjoitus käsittelee kesällä 1968 Porissa, Kokemäenjoen suistossa suoritettuja linjatakseerauksia, joiden tarkoituksena on ollut selvittää, suurenko osan paikallisesta ruokokerttus- ja pajusirkkupopulaatiosta pystyy linjatakseerausmenetelmällä löytämään. Pajusirkut ja osa ruokokerttusista olivat yksilöllisesti värirengastettuja ja päivittäin tarkkailun kohteena, joten todelliset parimäärät olivat tiedossa.

Linjatakseerauksien tulokset ovat taulukossa 1. Pääsaran todellinen pajusirkkumäärä oli munintakauden alussa 16 koirasta, joista yksi pariton, ja pääsaran eteläosassa (kartoissa kirjainten H ja M välinen alue) oli 8—9 ruokokerttusparia. Pääsaran pajusirkuista osui linjanvetoon keskimäärin 40 % paikallisista linnuista (laulavia koiraita kriteeriona käyttäen 20 %) ja ruokokerttusista n. ⅓. Myöskään kartoitusmenetelmän perusteella ei kaikkien ruokokerttus- ja pajusirkkukoiraiden reviirejä voitu paikallistaa (kuvat 1 ja 2). Tutkimusalueen lintumäärä oli 310—320 paria, eli n. 1300 p./km².

Erityistä huomiota on kiinnitetty pesimäkierron vaiheen vaikutukseen takseerauksen tehokkuudessa. Koska pajusirkkukoiraat heti parinmuodostuksen jälkeen ja toisaalta pesäpoikasvaiheen alkupuolella laulavat hyvin vähän tai eivät ollenkaan ja koska 50 % pajusirkkuhavainnoista koski laulavia koiraita, vaikuttaa pesimäkierron vaihe selvästi takseerauksen tehokkuuteen.

Dominanssilaskelmien tekoon ei yhden tai muutaman lähekkäisen takseerauskerran perusteella ole syytä ryhtyä, mikäli vertailtavat lajit ovat takseerauksen aikaan pesimäkierron eri vaiheessa.

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Note. After this article went into press I found a pertinent paper by BELL, B. D. *et al.* (1968) "Problems of censusing Reed Buntings, Sedge Warblers and Reed Warblers." Bird Study 15: 16—21.