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A technique for censusing territorial song thrushes *Turdus philomelos*

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Previous studies have shown that it is difficult to estimate accurately the breeding numbers of song thrushes. This has been confirmed in our Białowieża study, where actual numbers were derived from a combination of special dusk and dawn counts of singing males, from intensive nest searching and from colour-ringing. Empirical tests have shown that the improved (combined) mapping technique yields estimates which are only 62–78% of actual numbers. The result is negatively correlated with the song thrush densities ($r = -0.852$, $P<0.05$). However, the efficiency for the low-density blackbird *Turdus merula* population was found to be close to 100%.

It is suggested that almost all territory mapping technique density values published so far for the song thrush are underestimated by 30–60%, depending on the type of method used. Single-visit relative counts may record only about 20% of actual values, lower than for other species. All methods, when applied under Central European conditions during the usual period of late morning, tend to record mostly unmated males, which constitute only a tiny and fluctuating fraction of the population.

The species can easily be mapped, however, during a very early morning period or (with some complications) during late-evening semi-darkness. Thus, to start counts earlier (about one hour before local sunrise) would embrace more song thrushes or other thrushes, as well as some other species, e.g. *Locustella fluviatilis, Erithacus rubecula*, and some pigeons.

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1. Introduction

It has been known a long time (Siivonen 1939, Ytreberg 1972, Slagsvold 1973a, b, Enemar et al. 1976) that the song thrush, *Turdus philomelos*, is a very difficult species to census. It requires special effort to get reliable results. Various improvements were suggested such as nest-searching, emphasis on early breeding season visits, special evening counts. These improvements were incorporated into our combined territory mapping technique, having 9 daily and one evening visit to each plot (Tomiałojć 1980, Tomiałojć et al. 1984), and we hoped that our efficiency in recording this species would become comparable to that of most other species, i.e. close to 100% ± 10% field error. Even the 1979 test, showing 28% underestimation in the song thrush (Tomiałojć 1980), was thought to be an exception resulting from bad weather that year. Our recent empirical test has shown, however, that our previous belief was a typical example of wishful thinking, common among census workers who are reluctant to check their figures.

In 1986, an intensive population dynamics study of the song thrush breeding ecology was started in the Białowieża National Park. The present paper is a by-product of that study; it enabled us to compare the combined mapping method results with true numbers.

The main aim of this paper is to show:

1) How incomplete our standard monitoring census results are for the song thrush, and how they might be improved.
2) Whether the estimates of the territory-mapping technique can depend on population density.
3) How the song thrush singing activity depends on time of day.

2. Study area

All field work was conducted in the primeval lowland forest of the Białowieża National Park, mostly on the permanent monitoring plots which have been under intensive research for 13 years. See Tomiałojć et al. (1984) for details of habitat description and general characteristics of the study area. Three plots of 30–50 ha were chosen in 1986 for the present study, and in 1987 the work was focussed on only two. These were representatives of two types of forest habitats:

1. *Oak-hornbeam forest with linden and spruce* (Tilio-Carpinetum); Plot W (50 ha in size), embracing our permanent monitoring plot of 25.5 ha. It is a forest stand of climax character, remaining for over 65 years without much human impact. The multispecies, multilayer and up to 45 m high forest canopy is closed, voluminous, though some windbroken gaps show through (about 3 ha in size jointly).

The bush layer is fairly sparse and the ground fairly dry, allowing easy penetration.

In 1986 another 30 ha oak-hornbeam plot (C) was monitored. It exemplified the forest-interior conditions, though no significant differences were found in comparison with plot W.

2. *Ash-alder riverine forest with an admixture of spruces* (Circaceo-Alnetum); the whole of Plot K (33 ha) has been our monitoring plot since 1975. It embraces a stand on swampy ground with many uprooted trees and a luxuriant bush layer. Its mostly two-layer canopy is less voluminous, open in many places, with many small gaps in trees, and barely reaching above 30 m. The area is rugged and difficult to walk through silently, thus reducing the censusing efficiency.

3. The methods

The actual numbers of song thrush territories have been derived from total mapping relying on a combined effort of two observers (the authors) visiting each area every second day for the period from 4–5th April to the end of June (in 1986) or to mid-July (in 1987). It should be mentioned that most Białowieża song thrushes attempt two broods between early April and late June, while about half the population starts a third one late in June or early in July. Totally, 87 nests were being monitored in 1986, while their number rose to 141 in 1987, which is roughly over 80% of all nests built. "Paper territories" were delineated on the basis of all types of clues available, though special attention was paid to simultaneous singing of neighbouring males, which were mostly recorded at twilight during 25–30 special surveys. Some individuals were ringed (young) or colour-ringed (adults). This helped to trace a few shifts of territory boundaries occurring during the season.

Early-morning (dawn) and late-evening (dusk) censuses deserve more thorough description. During both periods, the song thrush males sing with much higher intensity and regularity than at any other time of the day, and the most synchronized singing occurs at twilight. Unfortunately, such periods are rather short (last 20–40 minutes), which impels the observer to proceed quickly in semi-darkness. One observer can check a maximum of 12–15 hectares efficiently, and larger plots must be subdivided and covered by two observers, or covered during two visits. Both periods of intensive song thrush singing have positive advantages (see below), but also some disadvantages. For instance, during early morning (at dawn) the counts have to be started somewhat earlier than an hour before the local sunrise, which requires considerable discipline. Habitats with a high total bird density (above 80–100 pairs/ha) present another disadvantage, in that there is a possibility of "overshadowing" distant song thrush songs by other species singing near and loud, such as the blackcap *Sylvia atricapilla* or chaffinch *Fringilla coelebs*.

During the early part of evening surveys, birds sing from stationary positions, but their singing is not sufficiently synchronized to allow simultaneous recording. At twilight, song thrushes start very intensive and synchronized singing, which helps the observer considerably. Unfortunately at twilight a minority of song thrush males begin a "hysterical" song and fairly long movements between subsequent outbursts of singing. They apparently do not recognize the "song-territory" boundaries and were observed to wander across areas belonging to other males. The function of this behaviour, watched during about 100 evenings, is not fully understood; perhaps the birds do not recognize the territories, being high in tree crowns. This phenomenon creates the possibility of some errors of double and triple registrations, and care must be taken.

The standardized results collected for monitoring purposes since 1975 originate from an improved version of the territory mapping technique, also known as the combined mapping technique (Tomiałojć 1980). This version differs from the international standards for territory mapping in that it stipulates longer visits to the plots, intentional "hunting" for contemporary records of singing neighbours, one additional evening survey for song thrushes and for other evening-active birds, and a certain amount of nest-searching during standard visits, made possible by their lower speed of penetration. This method yields close-to-absolute results for several bird species checked so far (Tomiałojć 1980, Paul & Roth 1983, Borowiec & Ranoszek 1984).

Table 1. Numbers of song thrush territories estimated by the combined mapping technique (Tomiałojć 1980) compared with the actual numbers.

	Oak-hornbeam Plot W (25.5 ha)			Oak hornbeam Plot C (30 ha)	Ash-alder swampy Plot K (33 ha)		Totals	
	1979	1986	1987	1986	1986	1987	1986	1987
Actual numbers (t)	12–13	15	20	13–14	22	26.5	50–51	46.5
Estimation (E)	9	11	13–14	10–11	14	16.5	35–36	29.5–30.5
E in % of t	72	73	68	78	64	62	70	65

In order to avoid subjectivity in judgements, the counts serving as a basis for this method were conducted by observers not acquainted with the actual distribution and abundance of the species, and two observers (T. Wesołowski and W. Walankiewicz) drew the "paper territories" and estimated their numbers.

4. Results and discussion

The results of the tests for the song thrush estimates obtained with the help of combined mapping techniques have appeared to be rather disappointing. Although more effort is required than for other census methods, the results are still only 62–78% of actual numbers (Table 1). Such data have been collected for 2–3 years from 2–3 plots, thus giving a reasonable number of replications of the test. The result was much worse than expected, and a 30% correction had to be applied to make the past figures obtained for the song thrush comparable with those for other species in the community. To visualize more clearly the consequences of such a difference, it can be stated that for years the song thrush was thought to be a bird in 6th and 9th dominance position in the Białowieża bird community (Tomiałojć et al. 1984), while in fact this is the second or the third most numerous species, after the chaffinch and sometimes after the robin *Erithacus rubecula* (in the past also after the wood warbler *Phylloscopus sibilatrix* — now on the decrease). Although the song thrush is so abundant, it can be hardly noticed during the hours of standard bird censuses.

When comparing two kinds of song thrush maps for the same plot but derived from two census methods, it appears that in several cases the combined mapping "territories" embrace two or even two-and-a half of the true territories (Fig. 1 and 2). This means that still too low a number of simultaneous records of neighbouring males is registered during 9 standard (morning) and one evening visits.

4.1. Patterns in song thrush song activity

In looking for the reasons for such low detectability of song thrushes three factors have to be evaluated:

1) seasonal patterns in song activity,
2) daily patterns in song activity,
3) individual variation in song activity.

The uneven song thrush song activity throughout the breeding season is well pronounced in the Białowieża Forest results, and had already been taken into account in our method for bird censusing. It also appears to be very similar to the patterns described by Slagsvold (1973a, b) for the Norwegian population, if some shift in phenology is ignored. Recognizing this pattern, we always concentrated the simultaneous recording of song thrush to the two peak periods in its song activity: in the second half of April and in the first half of June. This solution does not now appear to be satisfactory enough. We do not intend to discuss this more thoroughly, because it was comprehensively analysed by Slagsvold, and census methodology needs practical solutions rather then very detailed descriptions of the patterns of bird activity.

The experience of the last two years lead to an emphasis being put on song thrush singing hours. This was also recognized by Slagsvold (1973a, b) when he discriminated between morning and evening surveys. However, as can be judged from his papers, both his survey periods apparently did not embrace song thrush singing at twilight, and he did not pay much attention to the simultaneous records of neighbouring males.

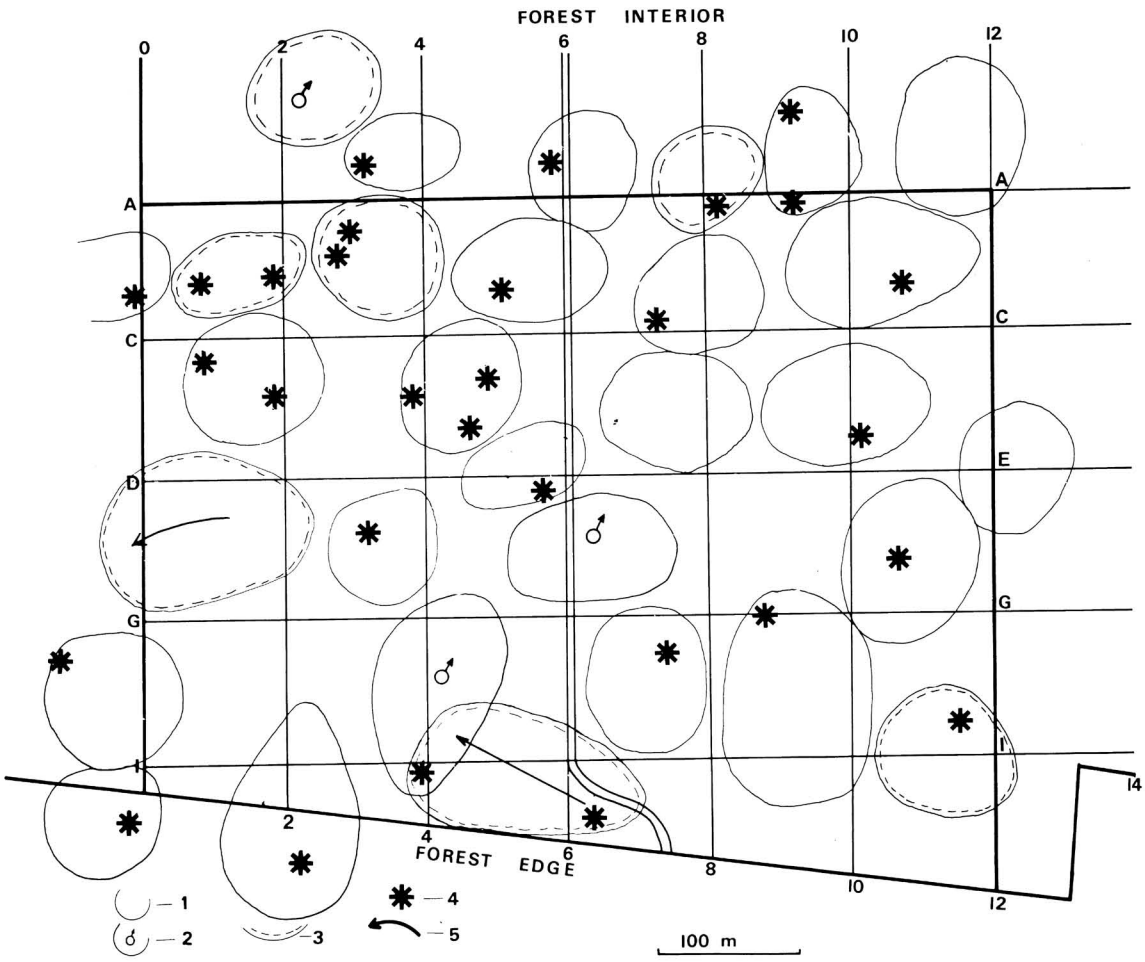

Fig. 1. Distribution and number of song thrush territories revealed on the 25.5 ha plot W during April–June 1987, based on censusing by two observers. — 1. Approximate size of song-territory. — 2. Territory of unmated male. — 3. Territory of individually marked pair or male. — 4. Active nest of first or second brood. — 5. Significant shift of territory with time.

Within the circadian rhythm, four distinct periods in song thrush singing activity can be identified:

1) Dawn, or early morning. The survey should be started already in semi-darkness, somewhat earlier than one hour before local sunrise. Birds sing vigorously and stationarily for 20–40 minutes, then cease abruptly.
2) Later in the morning. This is the period customarily used for bird censusing. Such surveys were started more or less at the moment of sunrise, sometimes up to one hour later. At this time of the morning usually only some song thrush males are vocal, and their song is poorly synchronized, except for two restricted periods (in April and in early June). Such low-intensity and non-synchronized singing may last up to noon, especially in wet or cloudy weather.
3) The afternoon. At that time there was no song thrush singing as a rule, hence the surveys were not performed.
4) Sunset. Song intensity increases again some 1–2 hours before sunset, and surveys were started about 1.5 hour before sunset and terminated about one hour after sunset, depending on cloud cover. The first part of this period was used for recording stationarily (but not always simultaneously) sing-

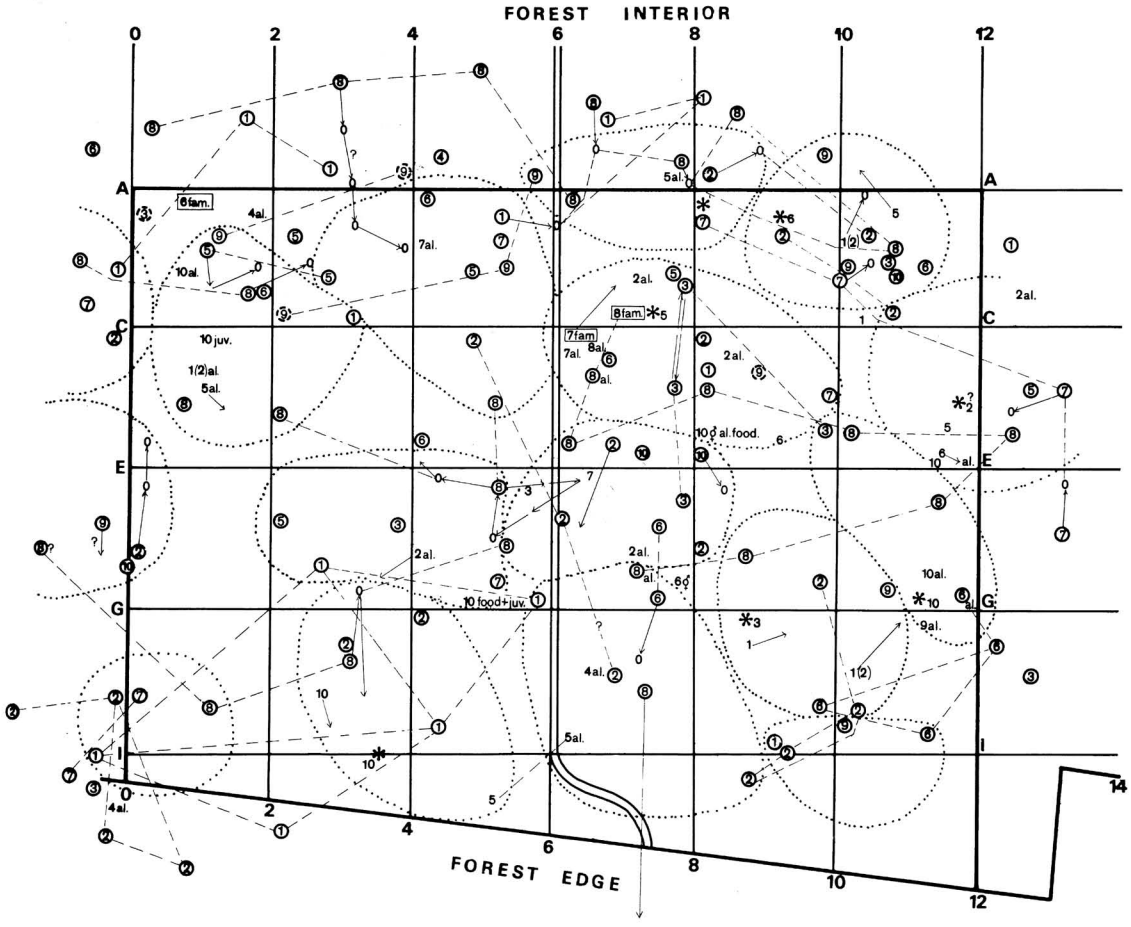

Fig. 2. Distribution and number of song thrush "paper territories" drawn on the basis of combined mapping data (from 9 late-morning visits and one evening visit in April–June 1987). Symbols according to the international recommendation for mapping methods, plus some additional symbols: al = alarming, fam. = family, * = nest found during mapping visits.

ing song thrush males and other evening active birds (chiefly *Turdus merula* and *Erithacus rubecula*). An outburst of "hysterical" and simultaneous singing sometimes co-occurred with erratic movements of some males. This usually occurred during the last 20–30 (40) minutes of their activity, and it was used for checking the simultaneous occurrence of neighbours.

In order to quantify the differences in song intensity during periods 1, 2 and 4, two relatively simple indices have been calculated (Table 2). The first index shows how many simultaneous records were obtained per one singing male. The second index indicates how many simultaneous records (forming the basis for objective separation of neighbouring territories) were obtained during one hour of observation. The latter index compensates for an unequal number of males observed or for simultaneous recordings in a particular census. Results indicate a *seven-fold* advantage of both surveys conducted in semi-darkness over the surveys performed during the usual time of bird censusing.

Song activity of the song thrush shows a differential seasonal variability independently within all three daily periods of its singing. This is shown in a generalized diagram (Fig. 3), which tries to discrimi-

Table 2. Effectivity of song thrush censuses performed at different times of day during April–June 1986 and 1987.

	No of surveys	Average time per survey (hours)	Singing males	Simultaneous song records	% simultaneous records per male	Simultaneous records per hour of censusing
Dawn survey (well before sunrise)	22	1.7	271	243	89	6.56
Morning survey	25	5.2	212	113	53	0.87
(April morning survey)	(11)	(4.7)	(127)	(83)	(65)	(1.59)
Evening (dusk) survey	31	1.8	388	377	97	6.55

nate different sections in an average breeding season. It should be kept in mind, however, that the breeding season shifts in time depending on the course of the phenological season (Slagsvold 1973a, b).

4.2. Which males sing when?

Data on the mating status of several Białowieża song thrush males, some of them colour-ringed, gave us an opportunity to evaluate roughly the patterns of individual variation in singing activity. It appears that during the early morning (dawn) survey, all or almost all males are vocal, disregarding their mating status. The same is valid for two shorter periods of evening chorus (in April and early June).

The most difficult time for bird censusing, however, is late morning, i.e. during a period when most bird counts are conducted. It appears that at that time only a minor fraction of song thrushes present on their territories have a chance to be recorded by an observer. Moreover, even when they are recorded, usually there are no simultaneous records of singing with their neighbours to allow objective discrimination between territories. The neighbours can be as close to each other as 20 m.

The Białowieża results also confirm most of Slagsvold's (1973a, b) conclusions concerning the correlation between the male status, or the state of its brood, and the intensity of its singing.

Firstly, during early season some territories on our plots were occupied for a short period by non-breed-

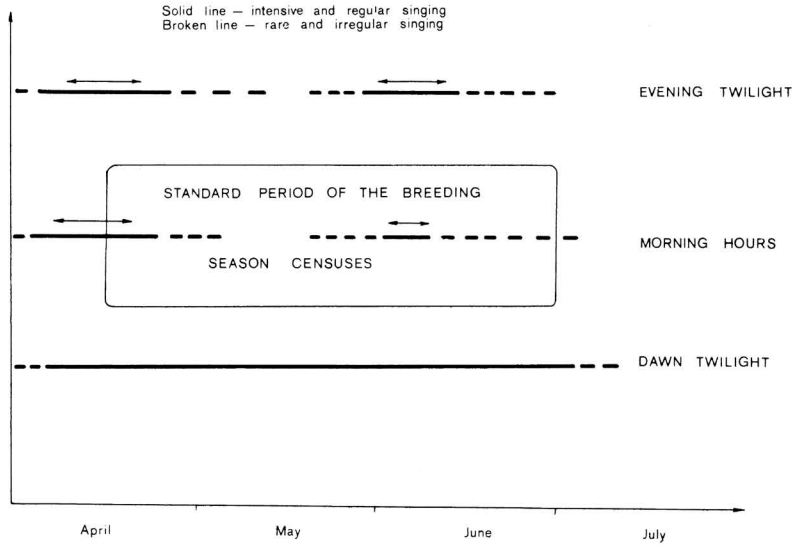

Fig. 3. Temporal patterns in song thrush singing.

ing and non-stationary males, probably migrants. Later on, these birds could not be found there. This makes the counts during the first half of April less reliable. Secondly, all males singing loudly and persistently during late-morning surveys after about the 20th of April, appear to be stationary but non-mated males. Their numbers fluctuate with the course of the breeding season due to:

1) disappearence,
2) obtaining a mate,
3) loss of mate by an earlier mated individual.

Two extreme cases of persistence in singing can be given:

1) A bachelor male singing on its territory between the 11th of April and 20th of June was recorded on 18 days out of 25 surveys conducted. It sung frequently during the whole period of light hours at a rate of 40–53 minutes per hour. Its song, when emitted from the top of high spruces, could be heard from a distance of 150 m, giving an impression of a much shorter distance. It seems that such males can be subject to double- or even triple-recording during the counts.
2) A mated male, present on his territory (with his nest found) between 13 April and 11 June was heard to sing only on 4 days out of 25 surveys. The chance of recording such males is very low with all the methods currently in use. These findings indicate that the late-morning singing of song thrush males cannot be taken as a representative sample proportional to the actual population size. Fig. 4 shows the tiny and fluctuating fraction of the population such males constitute, although at that time of day they produce most of the vocalization.

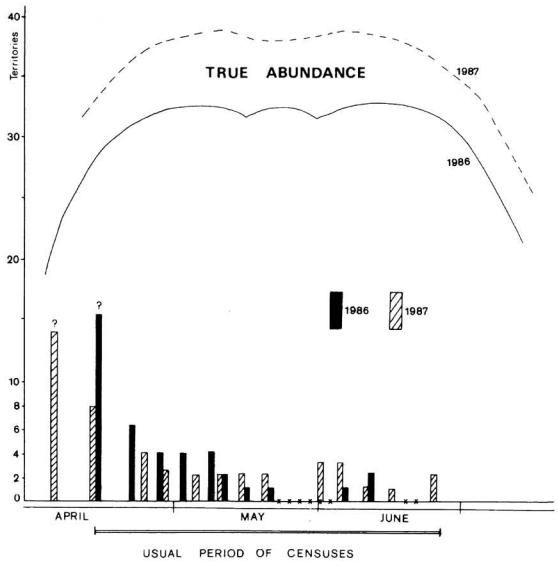

Fig. 4. The number of males, mostly unmated individuals, persistently singing during late morning in May (bars) in relation to the actual song thrush population size (curves, 32 territories in 1986 and 39–40 in 1987). The data from Plot W.

4.3. Reasons for good census results

It would be interesting to know why some past tests of the line transect method produced unexpectedly good results for the song thrush. We refer to an earlier comparison between the combined mapping technique results and the Finnish main-belt data obtained from a Finnish line transect method checked in Białowieża conditions in 1977 (Järvinen et al. 1978). Assuming that the mapping technique results (1.8 pairs/10 ha for song thrush) were roughly only 70% of the true abundance (as has been measured recently), the true values were about 2.6 pairs/10 ha. Remarkably enough, the value of 2.5 pairs/10 ha has also been derived from the main-belt data of the Finnish *single-visit* transect. On the other hand, the corrected survey-belt result was only 1.4 pairs/10 ha. How such a good agreement could be obtained during a single-visit (not repeated) count remains to be explained. It can be suspected that this was a consequence of:

1) restricting the counts to the period of early June when song thrush starts its second brood, with some increase in its song intensity,
2) the number of non-mated males being higher than in 1986–87,
3) a number of double-recordings of some males must have been included, which might have originated from the way the census was carried out, i.e. with the transect lines running parallel through the plot, thus probably crossing some territories twice.

Our results may have another limitation. They reflect the set of Central European conditions which probably influence song thrush singing. For example, under the wetter climate of the British Isles, song thrushes appear to sing more vigorously during late-morning hours, at least in parks (LT, personal observations). Furthermore, a considerable number of simultaneous records appearing on combined-mapping technique species-maps from Finland by T. Pakkala,

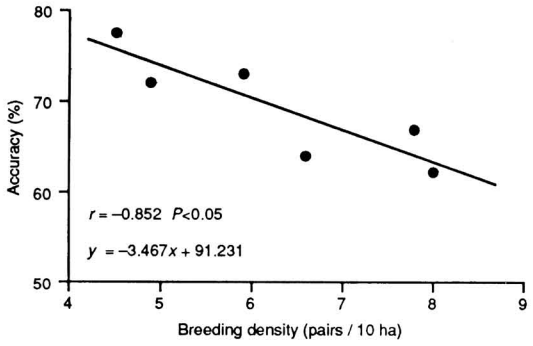

Fig. 5. The relation between the actual breeding density and the accuracy of the combined territory technique estimates for the song thrush.

J. Piironen and J. Tiainen suggests clearly better efficiency of late-morning censuses under conditions of the cooler and shorter Finnish breeding season.

Additional field tests for this species would be necessary to clarify these differences.

4.4. Density-dependence in census results

Most census methods rely on the assumption that they yield close-to-absolute data, or that at least their figures remain proportional to actual numbers. This means that at each density, the same proportion of birds is recorded.

Unfortunately, this basic assumption seems to be seriously unsound, chiefly in single-visit methods (DeSante 1981, Walankiewicz 1987). Surprisingly enough, the same tendency has been found in our combined mapping technique estimations for the song thrush (Fig. 5), though less pronouncedly.

This aspect of bird census methodology urgently needs more field tests to be evaluated properly.

4.5. How to make song thrush results comparable with those of other species?

One of the practical conclusions made on the basis of our findings is that it is necessary to introduce a 30% correction to our past results for the song thrush. We also suggest that an international standard for mapping technique may yield results constituting only 40–50% of actual song thrush numbers, well below those for other species. Hence, the number of highly efficient surveys conducted at twilight ought to be increased. This can be achieved without increasing the total number of visits to the plot, but merely by starting 2–3 visits from the beginning of dawn.

It is also suggested that it is necessary to check the results for this difficult species and for some others, when collecting data by means of single-visit relative methods of censusing. If the counts are conducted during late-morning hours in May, or through most of June, then the underestimation for this species may be as great as only 20% of actual numbers, thus two to four times the average efficiency known for other species.

4.6. The combined mapping technique accuracy for other species

The case of the song thrush should not be generalized too far, however, as it only applies to some atypical species. Most forest birds are active when the usual late-morning counts are made. The accuracy, or completeness, of this method is known to be close to 100% (Tomiałojć 1980 and others). To verify this accuracy, some new data collected and calculated in an analogous way to those for the song thrush, but obtained for the low-density blackbird *Turdus merula* populations, are shown in Table 3. These data show the close-to-absolute (98% on average) character of

Table 3. Numbers of blackbird territories estimated by the combined mapping technique (Tomiałojć 1980) compared with the actual numbers.

	Oak-hornbeam plot W (25.5 ha)			Oak hornbeam plot C (30 ha)	Ash-alder swampy plot K (33 ha)		Totals	
	1979	1986	1987	1986	1986	1987	1986	1987
Actual numbers (t)	7–7.5	6.5	5	5.5	7	5.5	19	10.5
Estimation (E)	6.5	6.5	5–5.5	6	7	5	19.5	10–10.5
Estimation in % of actual E	90	100	105	109	100	91	103	98

the results obtained with the help of this version of the territory mapping technique.

5. Conclusions

1. The combined version of the mapping technique yields figures which are only between 62 to 78% of the actual numbers of the song thrush territories. Furthermore, its efficiency is negatively related to the population density (r=–0.852).

2. Territory-mapping density values published so far for the song thrush seem to be underestimated by 30–60%, depending on the version of the mapping method and probably on the course of breeding season in relation to the time when the counts were made.

3. Sharp differences in the singing activity of individual song thrushes found during usual late-morning counts are much smaller, or disappear, when late evening (dusk), or chiefly early-morning (dawn) counts are made instead.

4. Consequently, relatively small adjustments of the daily count periods may yield song thrush numbers comparable with those for other species (e.g. for the Blackbird).

5. Field tests of various census methods and their variants are still of fundamental importance to the further development of bird censusing. This practical activity should not produce only figures, but figures that are reliable, in proportion to each other, and therefore, properly reflect actual situations.

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Notes and corrections added in proof

Page 236, add to left line 6 from bottom:

First and second brood results were treated separately and did not differ significantly (20 and 20.5 territories, respectively). If the occurrence of two neighbouring territories was based on only one simultaneous record of two singing males, occupied nests were used as supporting evidence. In uncertain cases special attention was paid to the site during subsequent surveys.

Page 236, right line 16 from top:

pairs/ha	should read	pairs/10 ha

Page 237, left line 13 from bottom:

and 9th	should read	to 9th

Page 242, continue sentence on line 3 from bottom with:

: the higher the song thrush density, the lower the proportion of territories recognized from singing-male counts.

Page 242, last sentence of section 4.5 should read:

If the counts are conducted during morning hours in May, or through most of June, then the estimation for this species may be only 20% of the actual numbers: two to four times lower than the average efficiency known for other species.

Page 242, table 3, last line:

Estimation in & of actual E	should read	E in % of *t*