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ACCURACY OF A VERSION OF THE SPOT-MAPPING CENSUS METHOD

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The spot-mapping technique (Williams 1936, Kendeigh 1944, Enemar 1959) is used frequently to census non-colonial bird communities on small plots during the breeding season. Ralph (1981) defines the method as relying on simultaneous observations of individuals either seen or heard. The "Combined Version" of the spot-mapping method (Tomialojć 1980) is a variant that emphasizes the importance of these contemporary contacts. It recognizes the utility of augmenting the standard census guidelines under varying field conditions. These additional efforts include searching for nests under high density conditions and adjusting length of visits to suit observer and habitat characteristics. Tomialojć's (1980) Combined Version census gave results closely matching actual densities of 2 species of *Phylloscopus* and one of *Troglodytes.* He suggested that additional tests of the method in high density situations were needed.

While these methods were developed to census entire communities, they also are applicable to censuses of single species. In this paper we compare results from a Combined Version census of a Wood Thrush (*Hylocichla mustelina*) population with information obtained by an independent, intensive study of the color-marked birds. We show that the Combined Version census can make an estimate within 10% of the density of a single species population.

METHODS

The study area was the northernmost 10.5 ha of the University of Delaware Woodlot in Newark, Delaware. This wood is a 15 ha oak-sweet gum-yellow poplar (*Quercus-Liquidambar-Liriodendron*) forest remnant (Longcore et al. 1966, Roth 1976) with well-defined boundaries (Fig. 1). Color-banded Wood Thrushes have been studied at this site since 1973. Our test uses information gathered during the course of that study.

The spot-map census consisted of 6 morning and 2 evening visits (29 h) by Roth to the area between 23 May and 7 July 1980. The average census speed was 3.45 h/10 ha. During these visits he recorded on maps (1:2400) all Wood Thrushes seen or heard and noted their activities. Starting points and directions of travel were varied, and routes zigzagged along or between lines of a 46 m grid system.

The Combined Version included conscious efforts to locate nests and assess the status of accessible ones and to make registrations of birds seen or heard simultaneously. Use of the latter records improved objectivity when drawing the composite "territorial" (see explanation below) boundaries. Due to the well-defined boundaries of the plot, all registrations were assumed to represent stationary males when effectiveness (effectivity of Enemar 1959) was calculated.

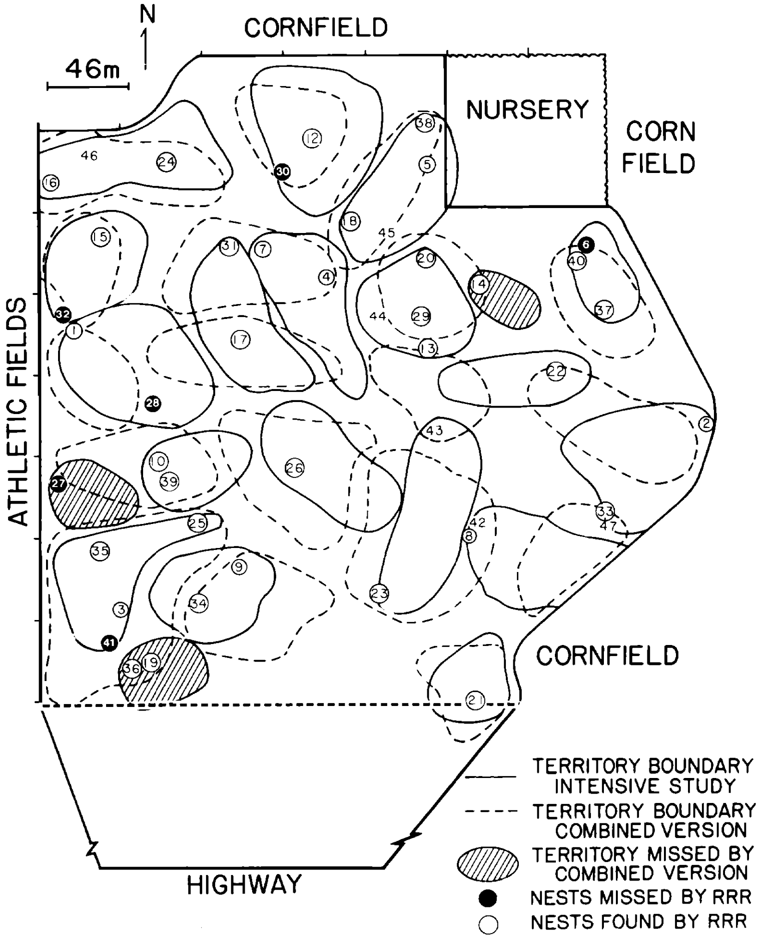

FIGURE 1. Map of the study area in the University of Delaware Woodlot showing Wood Thrush territories as determined by the spot-map census and the intensive study of the color-marked birds. Uncircled numbers represent nests built after the spot-map census was finished.

Independent data were collected by Paul and 2 assistants. Color-banding and observation of birds, as well as location and monitoring of nests, occupied about 300 h between 11 May and 1 August. Additional time was spent marking most of these birds in previous years. JTP prepared a "territory" map by connecting outermost observation points for each pair. The small overlaps observed were resolved by assigning half to each neighbor. We can express the population in terms of either pairs or stationary males (Enemar 1959) since JTP found no unpaired, stationary males.

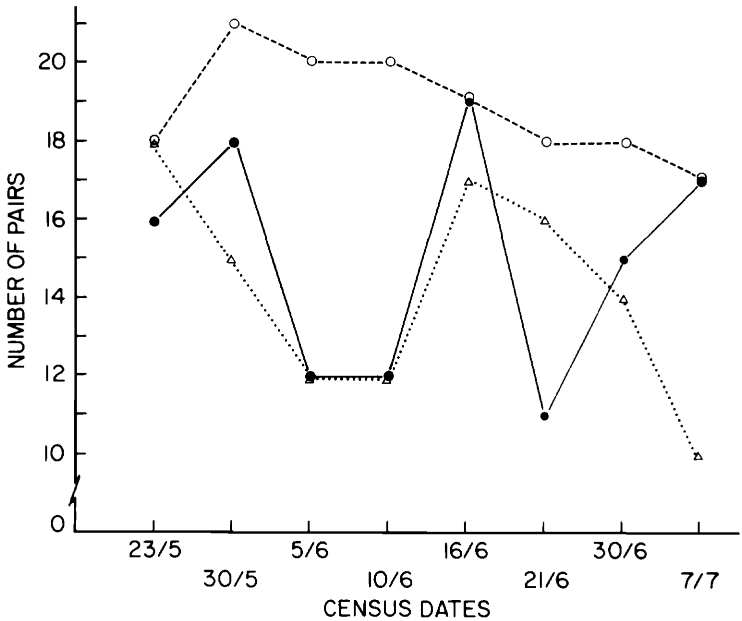

FIGURE 2. The solid line connects the number of pairs estimated by the census using information from each visit independently. The dashed line shows the number of pairs present on the plot as determined by the intensive study. The dotted line indicates the number of males estimated a posteriori from nest data to have been in the singing stage.

We use the term "territory" in this paper because the clusters of records represent territories. Our delineations are estimated territorial boundaries. Actually, the areas are seasonal activity centers with some of the boundary points defined by observed defensive encounters. JTP occasionally observed marked individuals as much as several hundred meters from their known activity centers. We excluded such observations when drawing the boundaries and eliminated any areas of overlap. Thus, the areas are not precisely home ranges either.

At the end of the season, and independent of the spot-map analysis, we used nest records and observations of marked birds to develop nesting chronologies. From these chronologies we determined egg-laying dates and estimated the number of males involved in the various stages of the breeding cycle on each census day.

RESULTS

JTP determined that 21 pairs used the area at some time during the season (Fig. 1). This is equivalent to a density of 200 pairs per km^2. Seventy-six percent of the birds were banded. Fourteen pairs had both sexes banded; 4 pairs had one member banded. Nesting and singing data were sufficient to establish the existence and general extent of the territories of the 3 unbanded pairs. The number of pairs present on each census day is shown in Fig. 2. Median date of laying for the first egg of the first clutch was 15 May.

RRR's census yielded a final estimate of 18 stationary males, a census efficiency (Ralph 1981) of 86%. The data collected on each visit were used independently to estimate at the end of the season the number of males present that day. The estimates show considerable visit-to-visit variability (Fig. 2).

The "species effectiveness," or mean percent males in the final estimate detected per visit (Enemar 1959), calculated on the basis of 18 males was 83% ($\pm$5.9 SE). Wood Thrush males not feeding young are the ones most likely to be singing (pers. obs.) and therefore the ones most likely to be detected. We estimated the number of such males for each of the census days using the nest chronologies and used these estimates as the base on which to calculate an "alternate species effectiveness." The resulting value was 108% ($\pm$10.4 SE), which means that for some single visits RRR overestimated the number of males.

RRR found 34 of 40 nests constructed during the census period (Fig. 1). (Nests 42–48 were built after the census period.) His territorial boundaries were reasonably congruent with those drawn by JTP.

DISCUSSION

Examination reveals why the very dense population was underestimated by 14%. One male, the owner of nest 14 (Fig. 1), did not provide a sufficient number of registrations to be recognized by RRR. He lost his first nest quickly to predators, left his area, and did not return. The area was not subsequently occupied by another pair nor was it usurped by neighbors. The owner of nest 27 suffered a similar fate. In this case registrations were sufficient to recognize the territory, but an interpretational error, discovered later in the analysis, caused the omission.

The third pair that RRR failed to identify fledged their first brood very early at nest 19, and their next attempt, at nest 36, was destroyed. RRR did not find the second nest until after it was empty. He incorrectly interpreted nest 35 as their third attempt. He noted suspicions that 2 pairs were involved but was unable to make the simultaneous registrations needed to settle the matter. An additional visit between 21 and 27 June would have allowed RRR to recognize nests 35 and 36 as contemporaries. Gaining a contemporary contact would have been subject to fewer constraints than obtaining the necessary nest information. This case supports the view of the Combined Version that contemporary registrations are of primary importance. In this case the accuracy of the census might have increased by 5%. Interpretation was made more difficult at this location because it was the only one which was bounded by potential Wood Thrush habitat outside the study area.

Nest searching has the most potential to be helpful for species like the Wood Thrush whose nests are relatively easy to find. In this study RRR found 86% of the nests, at a rate of 1.17/h, without searching intensively. This was probably due to the slow speed of the census and RRR's experience.

Tomialojć (1980) considered nest searching to be useful for separating clusters of certain species under some circumstances, including thrushes in high densities. However, Enemar et al. (1976) found that nests of the Willow Warbler (*Phylloscopus trochilus*) and Brambling (*Fringilla montifringilla*) frequently fell outside of the area of song registrations; they concluded that the combination of mapping and nest information could mislead estimates of the true number of stationary males in a dense population. Thrushes were censused in their study by nest-counting rather than mapping. Patrick Osborne (pers. comm.) concluded from studies in England that nest locations were of more value than registrations in territory positioning. Figure 1 shows that the nest site often provided one of the points of a territorial boundary in both sets of interpretations. They were sometimes the cause of RRR's mistakes in drawing boundaries, but about as often they improved the accuracy. Due to the reciprocal nature of the errors, some nests were included in the wrong areas, but the total number of territories was not affected. This is shown by the 2 groupings of nests: numbers 22, 33, 47, 8, 42, 43 and 4, 7, 12, 21. The territory containing nests 19 and 36 was the only one where there was no compensation for improperly assigned nests. We conclude that nest information may be helpful in separating clusters and determining boundaries, but without accompanying chronological information, it may also be confusing. Finally, nests sometimes provide the only indication of the presence of a pair in secretive species (RRR, pers. obs.).

The median date for initiation of first clutch (15 May) indicates that the census started too late. Census figures fell off sharply past 30 May, when many pairs had begun to feed young (Fig. 2). This agrees with the curve derived from the nesting chronologies and showing the number of potential singers. We also did not adhere to international standards (Anon. 1970) which call for 10 visits to a closed habitat. An additional visit prior to 23 May could have provided registrations for nest 14. However, visits before 23 May had greater potential for registering unsettled birds passing through the woods. Nest 27 was one of the latest starts, and we do not know if the pair had arrived by 23 May.

A species effectiveness of 83% means that an average of 15 males was detected per visit. Variation in the song cycle through the breeding season (Bell et al. 1973, Slagsvold 1973a, 1973b, Nilsson 1977, Best 1981) probably makes 100% effectiveness impossible.

If the "alternate species effectiveness" is near 100%, as ours was (108%), one can assume that a census has detected most of the males actively singing during most of the visits. A number of uncontrolled factors could have caused it to be slightly greater than 100% in our study. First, RRR may have misinterpreted double registrations on the single-visit maps when making the daily estimates. Second, our assumption that all registrations were due to resident birds is probably faulty. Third, some registrations during the early fledgling period when singing was reduced may not have been of songs but of scolds given by adults as RRR approached the young unknowingly. Finally, males may occasionally sing during the period when they are feeding first brood fledglings (Brackbill 1958). All of these factors could inflate the single-visit estimates. The agreement between census results and the number of potentially singing males masks inconsistencies on 21 June and 7 July that we cannot explain. Nonetheless, the figure indicates that the census was very efficient at detecting males in the active singing part of the breeding cycle. From this point of view, there is little room for improvement. A species effectiveness of 80% may approximate a theoretical maximum for Wood Thrush due to the nature of the breeding cycle. This is in line with published maxima of 70–80% for various species (Enemar 1959).

In our study an experienced census-taker concentrated on one species having no double territories or unmated territorial males on the study plot. Lengthy visits to this well-defined plot were made during a favorable period of the breeding season. Despite these advantages and the fact that species effectiveness was high, RRR still underestimated the total number of territories. The nest 14 territory might easily have been discovered by an additional visit, but the other 2 errors had random components. These random events must prevent many censuses from making the required number of registrations in all territories and may be one cause of the underestimation found in many standard spot-mapping studies (e.g., Bell et al. 1968, Haukioja 1968, Jensen 1974, Nilsson 1977).

The ecological relevance to the community of the 2 pairs which departed after their early nest failures may be questioned. If the census results are used to estimate energy flow through the community, then the census result is closer to the truth than the true total number of pairs. On the other hand, if productivity is of interest, these 2 pairs are no different from the 8 other pairs that were detected but failed to produce offspring. Also, they presumably kept others from selecting these sites, which were productive in previous years. We agree with Tomialojć (1980) that for general purposes the aim is to census all of those birds that attempt to breed, not just those that were successful.

Many factors already mentioned contributed to our high census efficiency while others, such as number and timing of visits, were not optimal. RRR's efforts suggest that a Combined Version spot-mapping census of a Wood Thrush population will at best detect about 90% of the total number of stationary males, if the visits are spread out over a period typical of a community census. The 16 June visit alone registered 100% of the males present that day, and 90% of the total number of males, suggesting that a few visits concentrated around this date would give acceptably accurate results. Extrapolation of these results to a community census depends on the existence of comparable results from other species (Best 1981).

SUMMARY

The accuracy of the Combined Version variant of the spot-mapping method was tested by comparing the results of an 8-visit census with the results of an independent, intensive study of a banded population of Wood Thrushes. The census found 18 of the 21 pairs that used the area at some time during the breeding season. The census might have been improved by 1 or 2 additional visits. Nest searching provided information on territorial boundaries but was confusing when chronological data were lacking.

The census effectively detected males in the singing stage of their breeding cycles. On average, 83% of the males were detected per visit. This may be near the maximum possible since some portion of the male population is quiet during most parts of the breeding season, e.g., when feeding young. We conclude that this type of census will discover about 90%, at best, of a population of Wood Thrushes. A 100% registration of the males present on one day, suggests that a few visits closely spaced around an optimum date would give acceptably accurate results for single species.

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