An Examination of Migration in Song Sparrows Using Banding Recovery Data

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ABSTRACT

We used bird banding recovery data to document migration behavior in Song Sparrows (*Melospiza melodia*). We show migration movements of 126 individuals based on locations of their initial capture during normal breeding period and subsequent recovery during winter, or vise versa. Ninety percent of Song Sparrows in western North America were non-migratory. Many Song Sparrows in eastern and central North America migrated to the southeastern United States, but others remained in their breeding area year-round. We tested for relationships between breeding latitude, migratory status, and migration distance, and for differences in migratory behavior between adult and young birds. Proportion of birds migrating increased with breeding latitude. Individuals breeding at higher latitudes migrate farther than those breeding at lower latitudes. Wintering latitude had the reverse effect; individuals wintering at low latitudes tended to be migrants that travel longer distances to their breeding areas.

INTRODUCTION

The management and conservation of birds requires an understanding of their ecology and life history (Perrins et al. 1991, Martin and Finch 1995). This is especially true for migratory species, which spend up to one-third of their lives in between breeding and wintering areas (Moore et al. 1995). Song Sparrows breed throughout much of the United States and Canada and their winter ranges are also are well known (Root 1988, Rising 1996). Based on Christmas Bird Count data, largest winter concentrations of Song Sparrows are in the southeast United States (Root 1988). However, migration patterns of this species have not been studied in detail.

Aldrich (1984) examined banding data for Song Sparrows and concluded that they were highly migratory in some areas and residential, or partially migratory in others. Nice (1937) found that during her eight-year study in Ohio, many Song Sparrows left the area in winter, while others remained as permanent residents. Nice suggested further that migratory status was under genetic control but also influenced by weather conditions in winter. Little else is known about migration in Song Sparrows and almost nothing is known about their specific migration routes in North America.

By incorporating the large amount of bird banding recovery data available for Song Sparrows into a geographic information system (GIS), we are able to describe in detail the migratory behavior of Song Sparrows. Bird banding recovery data provide information on where individuals go and can be used to elucidate relationships between aspects of migration and climate. These data also allow us to test for differences in migration behavior between young and adult Song Sparrows. In particular, we examined the effect of breeding and wintering latitude on migration tendency. We also examined relationships between breeding latitude and migration distance under the assumption that those breeding furthest north would be those individuals making the longest migrations. For comparison, we tested for relationships between wintering latitude and migration distance. We also asked if migration status or distance migrated differed in young and adult Song Sparrows. Finally, we illustrated main routes of Song Sparrow migration in eastern North America and the distribution of resident Song Sparrows in eastern and western North America.

METHODS

Data for this study comprised all records of Song Sparrows that were banded and subsequently recovered in North America, as supplied by the Canadian Wildlife Service Bird Banding Office, Environment Canada, Hull, Quebec. These data included recoveries of dead or live Song Sparrows by the general public, as well as live birds recaptured by bird banders other than the original bander. Not included in our data are recaptures of Song Sparrows by the same bander, as these data are not compiled routinely by the Bird Banding Office. The initial data set contained over 17,000 returns of Song Sparrows, dating from 6 Oct 1914 to 15 Jul 1998. For each record, locations of banding and recovery were provided to the nearest 10' block. Dates of banding and recovery, along with various other pieces of information about the bird were also provided, though our focus here was on banding and recovery locations. To identify breeding locations, we extracted only those records of birds banded during the normal breeding season of Song Sparrows, which we defined as 1 Apr to 30 Aug (Nice 1937, Arcese and Smith 1988). We identified wintering locations by extracting records of birds banded during the normal wintering period, which we defined as 1 Jan to 29 Feb. From these data we then extracted all birds recovered subsequently in the alternate period. This procedure provided us with 1565 records of Song Sparrows banded on their breeding range that were recovered subsequently on their winter range, or vise versa.

Migration routes – To describe migration routes, we first identified migrants as those birds recovered outside of the 10' block in which they were banded. For each of these birds we plotted their banding location and recovery location on a base map of North America. Song Sparrows may not migrate in straight lines, but connecting breeding and wintering locations by lines indicate general movements of birds between breeding and wintering ranges. For some birds, interval between banding and recovery was greater than one year. In these cases lines between points do not represent direct movements; instead we assumed that each bird's breeding and wintering location was in the same area each year, and that the time lag between banding and recovery was not important to our general purpose in this paper.

Migratory status – We defined "residents" as those individuals with banding and recovery locations in the same 10' block for both breeding and wintering seasons. However, some individuals recovered outside of the 10' block in which they were banded moved relatively short distances and may have been "dispersers" rather than true migrants. Therefore, to identify true migrants we first calculated the distance that all birds moved using the great circle distance formula, which calculates distance between two points indicated by latitude and longitude coordinates. We next calculated the general compass direction of each movement and then

Table 1. Counts of Migratory Song Sparrows in Each Direction and Distance Class.

	Distance Moved (km)						
Direction	**<50**	**<100**	**<250**	**<500**	**<1000**	**<2000**	**Total**
NW	0	0	2	0	0	0	2
W	7	0	0	0	0	0	7
SW	1	2	2	12	36	28	81
S	5	0	1	0	0	0	6
SE	0	0	0	1	1	0	2
E	1	1	0	0	0	0	2
NE	0	0	0	0	2	0	2
Total	**14**	**3**	**5**	**13**	**39**	**28**	**102**

determined the number of birds moving distances less than 50, 100, 250, 500, 1000, and 2000 km (Table 1). Based on these data, we defined birds that moved less than 250 km as dispersers and pooled them thereafter with residents because of the lack of strong directional tendencies. All birds that moved 250 km or more showed strong directional tendencies and were considered true migrants. It is possible that short distance, altitudinal migrants, if they occur, went unrecognized because of these definitions.

Migration tendency and distance – We pooled birds banded within the nearest 1° block by rounding to determine how breeding latitude and migratory status were related. This gave us 14 breeding latitude classes (33° to 47°) and 18 wintering latitude classes (30° to 47°). We then calculated the proportion of migrants in each class and used a Spearman Rank Correlation test to compare the proportion of birds migrating to breeding and wintering latitude. We excluded from these analyses all birds banded west of 100° W longitude because birds banded in western North America were primarily residents. We also used simple linear regression to test for an effect of breeding or wintering latitude on distance migrated.

Differences in migration status between young and adult Song Sparrows in eastern North America were tested using a chi-square test. We tested for a difference in migration distance between young and adult individuals using a t-test, after transforming distance by Log_{10} to achieve an approximately normal distribution for distances. Birds banded as nestlings and those identified as "hatch-year" birds were pooled as juveniles. Second- and third-year birds were pooled with the "after-hatch-year" birds as adults.

RESULTS and DISCUSSION

Most records for migrant and resident birds were from the Eastern Appalachian and Coastal Flyways (Figs. 1A, 1B). The few recaptures of Song Sparrows in the Midwest, as compared to elsewhere, probably results from unequal sampling effort across North America. Breeding locations of residents were widespread over the range of areas covered by banders (Fig. 1B). The fraction of birds migrating differed between eastern and western regions (X^2=17.49, n=1549, p<0.001). Song Sparrows in western North America were largely sedentary (16 migrants out of 449 birds) as was expected from studies of local dispersal in the Pacific Northwest (Arcese 1989) and California (Marshall 1948a, 1948b, Johnston 1956a, 1956b). Most birds that did move traveled less than 20 km. An exception was a bird banded in the winter in southern California that returned 1190 km to western Oregon. A second bird made a smaller movement from southern Oregon to winter in western California (Fig. 1A). Mild climates in areas in the west may preclude the need to migrate. However, Song Sparrows are common breeders at middle elevations in mountains throughout the west, where banding is rarely undertaken. Thus, we expect that altitudinal and longitudinal migration by Song Sparrows occurs in western North America, but that it is not well documented.

Song Sparrows in eastern North America breeding within the same 10' block may migrate, traveling up to 1500 km (Fig. 1A), or may remain as a resident. This indicates that individuals in local populations responded differently to changing environmental conditions in fall, as suggested originally by Nice (1937) for her study population in Ohio. Aldrich (1984) also suggested that individuals varied in migratory tendency in certain ecoregions of North America. Taken together, these observations and our own support the characterization by Terrill and Able (1988) of Song Sparrows as "obligate partial migrants." However, our results also showed that migratory tendency varies widely across the breeding range of Song Sparrows, and they suggest that in many parts of the range populations are resident year-round. To the degree that migratory tendency is under genetic control in Song Sparrows, this also suggests that local populations vary genetically.

Almost all individuals that migrated along the East Coast traveled in a southwest direction (Table 1) and most ended up in the southeastern United States, where Song Sparrows are known to concentrate in winter (Root 1988). An exception to this pattern was seen for two individuals that moved northeast from locations near New York City to winter in mainland Nova Scotia. Each of

Figure 1A. Generalized migration movements by Song Sparrows between breeding (circle) and wintering (triangle) locations, based on banding and recovery data. **B.** Distribution of resident Song Sparrows in North America; "resident" defined as banding and recovery locations within same 10' block for both breeding and wintering season. Circles represent more than one record in some cases.

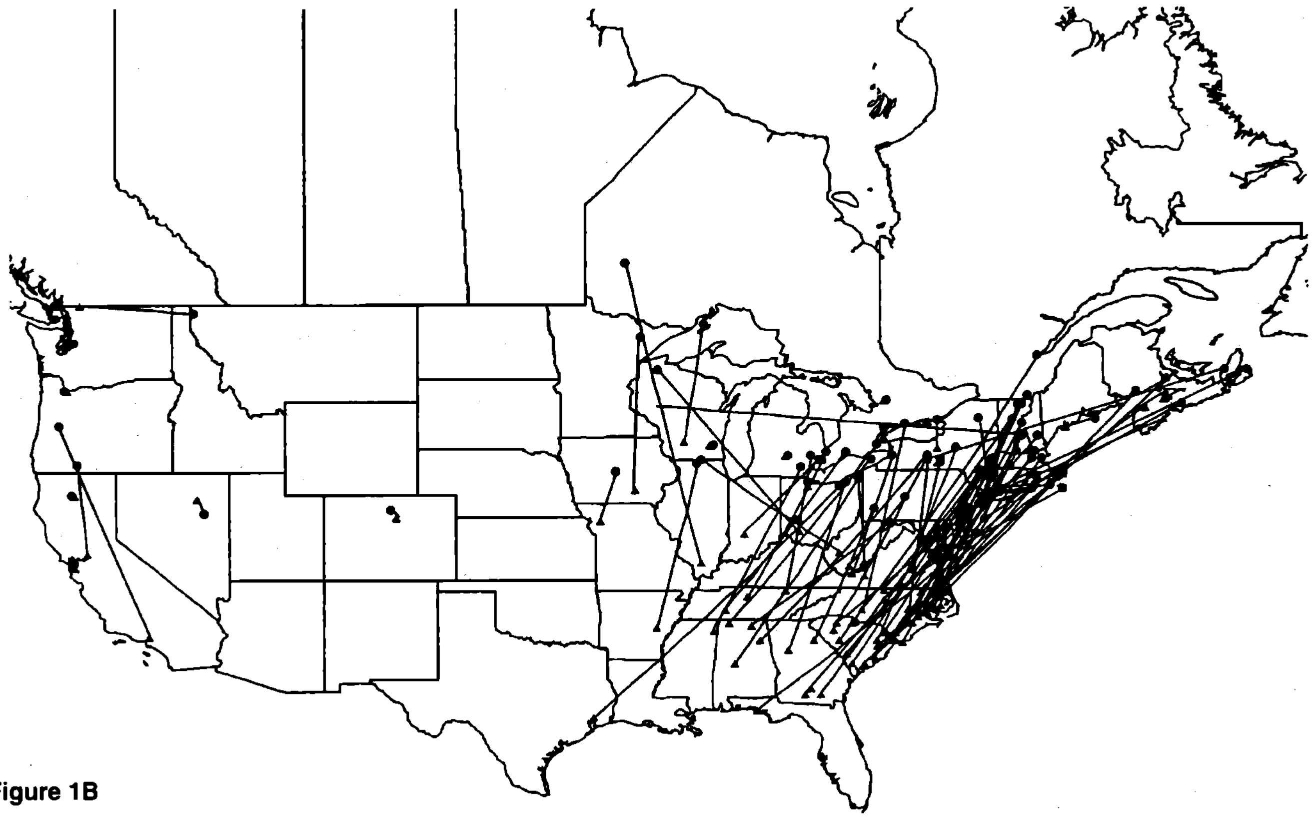
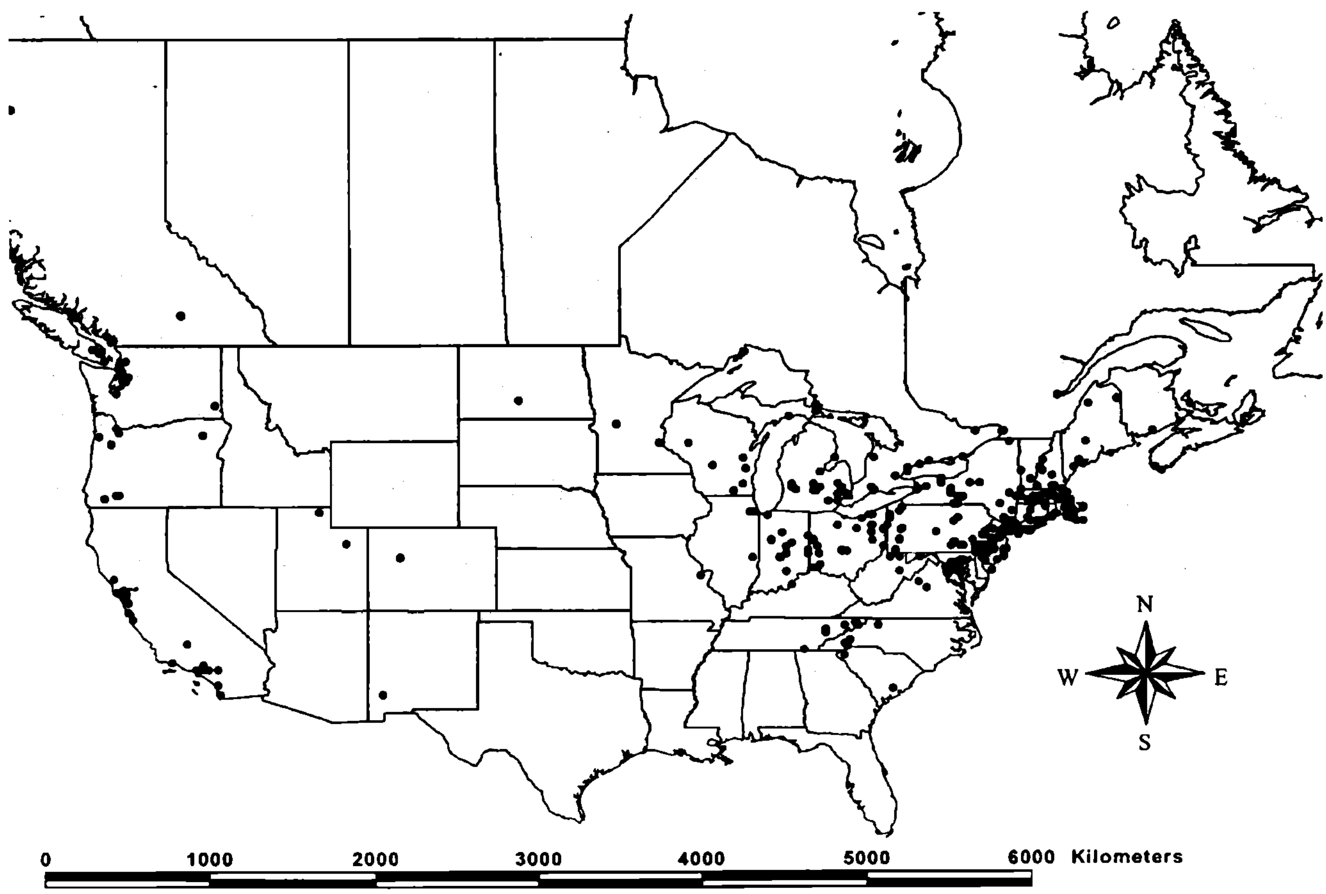


Figure 1B



these individuals was recovered in the winter immediately after their initial summer banding, implying a direct post-breeding movement northeastward. Although unusual, these recaptures are consistent with radar studies of land bird migrations on the East Coast. Richardson (1972, 1976) observed on certain occasions a "reverse migration" by small numbers of land birds that flew northeast from New England, across the Gulf of Maine, to mainland Nova Scotia in the fall. Richardson found that this reverse migration occurred almost exclusively with winds from the south, southwest or west. Richardson was unable to identify which species undertook these movements but noted that both passerines and non-passerines were involved. The fact that two Song Sparrows migrated to and wintered in Nova Scotia suggests either a purposeful migration northward or a repeat of accidental migrations somewhat miraculously recorded by banding recoveries. Thus, we describe these migrants in some more detail.

One reverse migrant was banded as an after-hatch-year during breeding in 1960 and found dead in Nova Scotia the following winter with no cause reported. The second bird was banded at an unknown age in summer 1961 and reported killed by a cat the following winter in Nova Scotia. Song Sparrows do winter in Nova Scotia, as we show here by the identification of several non-migrants in the area (Fig. 1B). Christmas Bird Count data also indicate an average of two to three Song Sparrows per 100 party-hr in Nova Scotia (Root 1988). Thus, even if the two migrations to Nova Scotia were accidental, such birds might be expected to survive the winter in Nova Scotia despite their unnatural displacement. The fact that both birds did not survive leaves open to question the existence of regular migrants from New England to Nova Scotia.

Breeding and wintering latitude each appeared to be related to migration behavior in Song Sparrows. Breeding latitude was related positively to migration status, such that individuals that bred further north were more likely to migrate than birds that bred further south (Fig. 2A). Birds that wintered the furthest south were also more likely to have migrated from breeding areas in the far north, whereas birds that wintered further north generally moved shorter distances between wintering and breeding areas (Fig. 2B). As expected from these results, migrants breed at higher latitudes on average than do residents (means = 42.3° vs 40.7°, respectively; $n = 1116$, $p < 0.001$) and they winter at lower latitudes than do residents (means = 37.5° vs 40.8°, respectively; $n = 1116$, $p < 0.001$). Overall, our results suggest that Song Sparrows breeding at high latitudes employed a leapfrogging strategy in migration, in which they flew over mid-latitude residents and short-distance migrants, perhaps to avoid competition in populations wintering at middle latitudes.

We found no difference in migration behavior between hatch-year and adult Song Sparrows. The proportion of migrants that were hatch-year (10.2% of 236) versus adult birds (7.8% of 580) was similar ($X^2 = 1.91$, $df = 1$, $p > 0.10$). The migration distances of after-hatch year (mean = 849.49 km, standard error = 55.62 km) and hatch-year birds (mean = 884.78 km, standard error = 71.3 km) were also similar ($t = -0.39$, $n = 69$, $p = 0.69$). Thus, the patterns we observed with respect to migratory behavior and latitude were not the result of differences in the average age of birds that bred at higher or lower latitudes.

ACKNOWLEDGMENTS

This study could not have been completed without the work of the thousands of dedicated ornithologists and volunteer bird banders who submit their data each year. We are grateful to the staff of the Canadian Wildlife Service Bird Banding Office, who meticulously compile and store these data, and who provided this Song Sparrow recovery data upon our request. Justin Brashares provided helpful comments on the manuscript.

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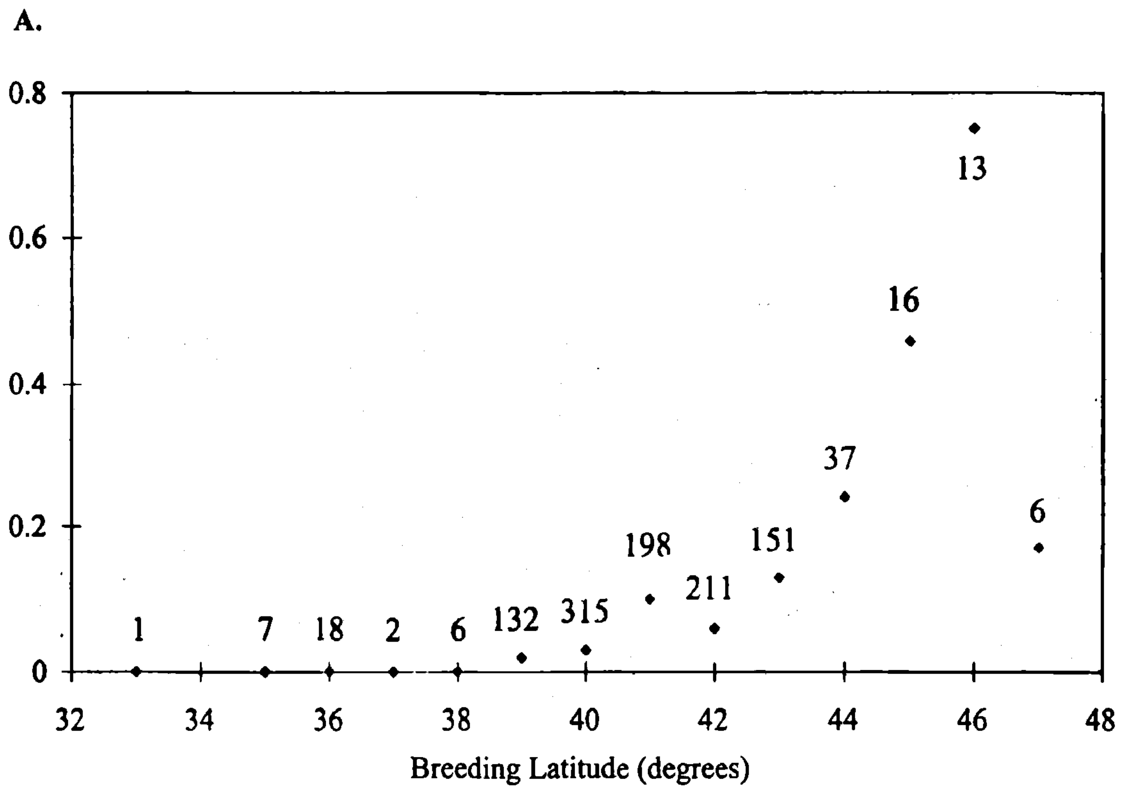
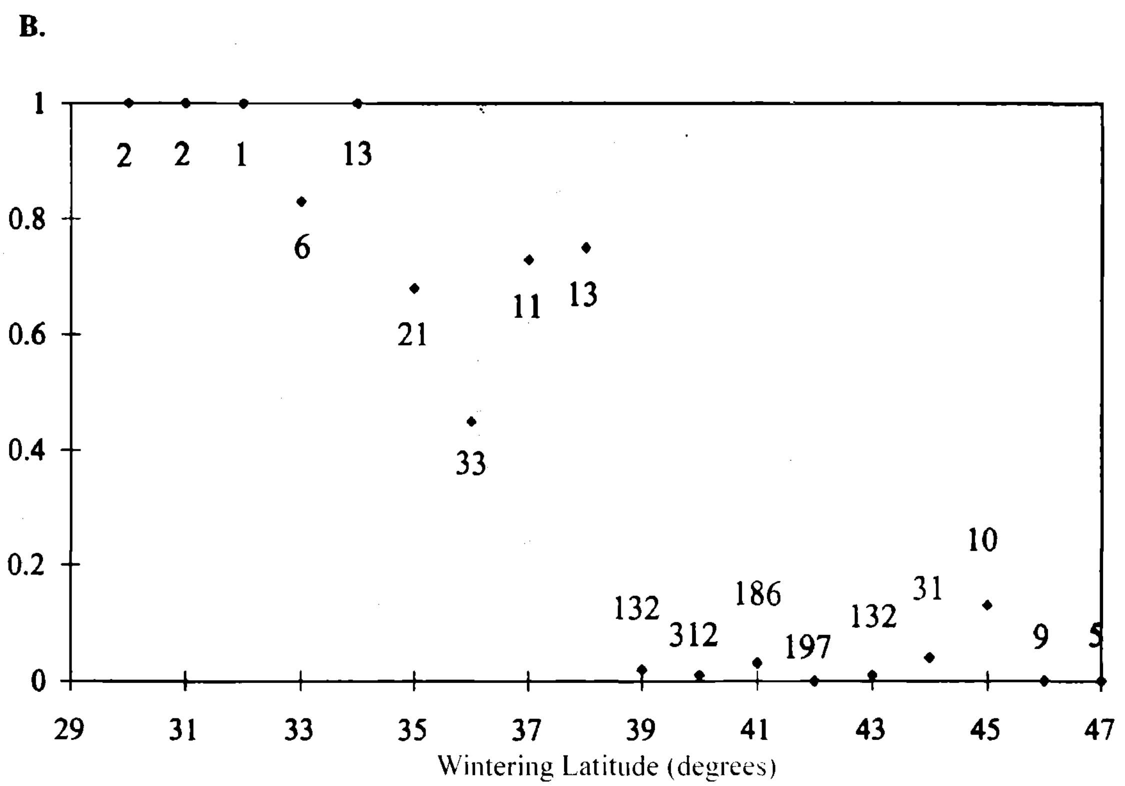
Figure 2. Relationship betwen migration status and (A) breeding latitute ($R_s = 0.70$, $n = 1116$, $p < 0.01$) and **(B)** wintering latitude ($R_s = -0.9$, $n = 1116$, $p < 0.001$) of Song Sparrows. Sample sizes are indicated for each point.





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