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SYLLABLE SHARING AMONG NORTH AMERICAN POPULATIONS OF THE EURASIAN TREE SPARROW[1]

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Abstract. The nest advertisement and defense song of the Eurasian Tree Sparrow (*Passer montanus*) was examined for evidence of syllable sharing among populations. Twenty Eurasian Tree Sparrows were introduced into North America at St. Louis, Missouri in 1870 (Widmann 1889). The population subsequently expanded north and northeastward into Illinois and now numbers approximately 150,000 birds. Four populations were sampled, the closest site to St. Louis lying 85 km to the north. Jaccard's coefficient was used to assess the degree of syllable sharing among the populations sampled. Several syllables were found to be unique to one or two populations. A pattern of song similarity between populations was found that did not correspond to geographic distances between sample sites but may correspond to the direction of spread of the population.

Key words: Eurasian Tree Sparrow; Passer montanus; *vocalizations; syllable sharing; geographic variation; Illinois.*

INTRODUCTION

Studies of acquired vocalizations of oscine, suboscine, and nonpasserine birds have shown convincingly that they vary geographically (e.g., Marler 1952; Baker 1975; Mundinger 1975, 1982; Payne 1978; Slater et al. 1980, 1984; Baptista 1985). Song sharing or sharing of various elements of song, e.g., syllables, among populations has often been examined as an indicator of geographic variation and "dialects" in bird song (Lemon 1965, 1966; Kreutzer 1974; Mundinger 1975; Avery and Oring 1977; Baker and Thompson 1985; Lynch and Baker 1986). Mundinger's (1982) survey suggests that the absence of song and syllable sharing is uncommon among oscines. Recent studies also suggest that the pattern of variation seen in the vocalizations of many birds is a result of cultural evolution due to copying errors during learning (called cultural mutations, Jenkins 1978) and transmission of those errors within a population (Jenkins 1978, Slater and Ince 1979, Ince et al. 1980, Payne et al. 1981).

We examine the nest-site song of the Eurasian Tree Sparrow (*Passer montanus*) in North America for evidence of syllable sharing and thus of microgeographic variation in this type of vocalization in this species. The Eurasian Tree Sparrow is introduced in North America, 20 birds having been released at St. Louis, Missouri in 1870 (Widman 1889). The population has generally expanded north and northeastward into Illinois and now occupies a restricted range of approximately 22,000 km^2 (Barlow 1973). The size of the North American population is estimated at ca. 150,000 individuals (St. Louis and Barlow, in press). There is some evidence of song learning in the closely related House Sparrow (*Passer domesticus*) (Nivison 1978, Wickler 1982). In addition in *P. montanus,* Baptista (pers. comm.) reports a captive bird of this species imitating calls of the Oriental White-eye (*Zosterops palpebrosa*).

MATERIALS AND METHODS

Eurasian Tree Sparrow vocalizations were recorded in May, June, and July of 1985 in Illinois near Whitehall, Greene County; Jacksonville, Morgan County; Meredosia, Morgan County; and Beverly, Adams County. Recordings were made with a Uher 4000 Report IC tape recorder set at a tape speed of 19 cm/sec and a Dan Gibson P-200 parabolic microphone. Songs were analyzed using a Kay Elemetrics Sona-Graph 7800 and Unigon FFT Spectrum Analyzer using a

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TABLE 1. Number of birds, size of syllable pools, and number and percentage of unique syllable types in each population.

	Wh	Ja	Me	Bv	Totals
No. birds	26	22	23	5	76
Syllable pool size	164	152	125	33	474
No. syllable types	80	74	62	25	132
No. unique syllable (%)	28 (35)	23 (31.1)	11 (17.7)	4 (16.0)	66 (50)

wide-band (300 Hz) setting 0 to 8 kHz frequency range. Sonagrams were printed with a Kay Elemetrics Sona-Graph Printer 7900.

For analysis only nest-site songs were considered. Sample sizes are shown in Table 1. In *Passer* the nest-site song is used in mate-attraction and nest defence (Deckert 1962, Summers-Smith 1963, Nivison 1978). This vocal display consists of a sequence of individual "chirps," which we term syllables. The structure of the display is not stereotyped as in many oscines. A particular syllable may be repeated every 0.15 sec to 2.5 sec for a few seconds to a few minutes before a new syllable is introduced. At this time both syllables may be alternated for several seconds before the first syllable is dropped. At high levels of motivation a male may alternate more than two syllables, often repeating the syllables in the same sequence, and occasionally interjecting a new syllable. The time interval between syllables and the amplitude of the syllables within a bout is highly variable and depends on the motivational state of the bird. Bouts last from a few seconds to 10 min. Bouts are operationally defined as groups of syllables separated by intervals from adjacent groups of greater than 2.5 sec. Each male has a repertoire of several syllables (as many as 22) which it uses in the nest-site song.

Syllables were classified by visual assessment of their similarity into categories (types) (e.g., Lemon and Chatfield 1971, Marler and Pickert 1984, Lynch and Baker 1986) and a pool of syllables was developed for each of the localities. Slater et al. (1984) found a high degree of agreement among several observers enlisted to visually classify Common Chaffinch (*Fringilla coelebs*) song types. Lynch and Baker (1986) found that methods such as digitization (e.g., Field 1976, Miller 1979), which may be potentially more objective, gave unsatisfactory results for the classification of Common Chaffinch syllables. These methods show a low similarity between syllables which have very similar shapes but different patterns of temporal duration (Lynch, pers. comm.). Few dimensions of syllable variation are employed by these methods for comparison (Lynch and Baker 1986). Gestalt perception, in contrast, uses a much larger number of dimensions and is therefore potentially more powerful (Lorenz 1981).

The degree of syllable sharing between localities was assessed following Lynch and Baker (1986). The presence (1) or absence (0) of a syllable in the syllable pool of a locality was scored and Jaccard's coefficient (Sneath and Sokal 1973) was used to compare the resulting binary matrix. Jaccard's coefficient excludes negative matches. This is useful in this case because the absence of a syllable may be due to sampling, making the presence of a syllable more important in showing similarity between two samples. The resulting matrix of similarity values was transformed into a distance matrix by subtracting the values from one. The distance matrix was clustered using the unweighted pair-group method on arithmetic averages, UPGMA (Sneath and Sokal 1973). Principle coordinate analysis (Sneath and Sokal 1973) was also used to depict song distance information contained in the song distance matrix. Geographical distances between localities were measured directly from a map for comparison with song distances. Computing was done using the NT-SYS package of statistical programs (Rohlf et al. 1982) on the University of Toronto Computing System.

RESULTS

The number of birds, the total number of syllables (the syllable pool size), and the number of syllable types sampled at each locality is shown in Table 1. The total syllable pool (474 syllables) was used in constructing a classification of the syllables. This resulted in 132 syllable categories (types). Fifty percent of the syllable types were unique to one locality using this syllable classification (Table 1). The percentage of unique syl-

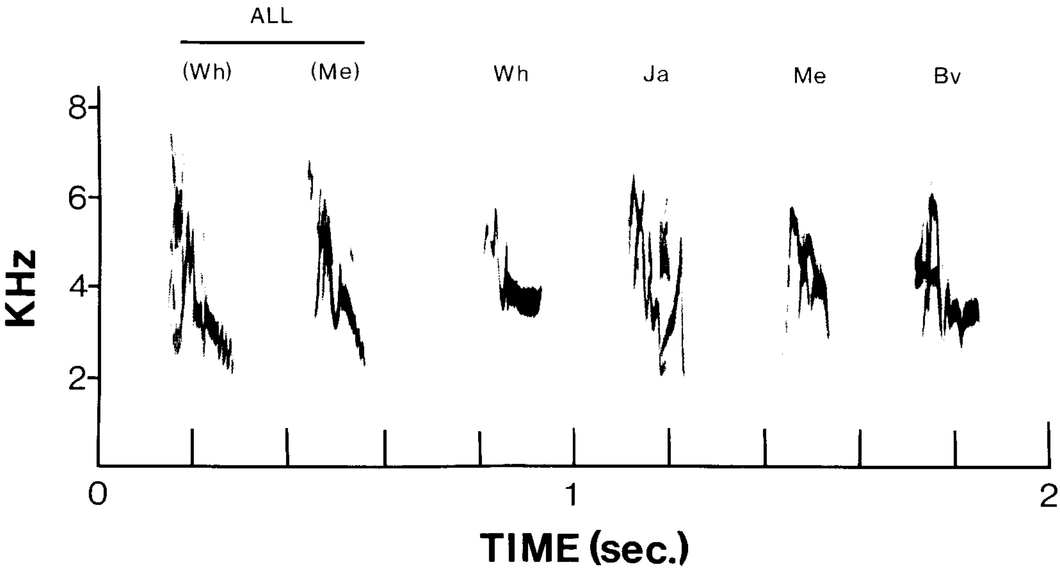

FIGURE 1. Example of a syllable type that was common to all four populations (first two syllables on the left) and examples of unique syllables from each of the four populations.

lable types found in each of the populations ranged from 16 to 35% (Table 1). Figure 1 illustrates spectrograms of syllables which were of varying occurrence in the populations sampled.

Analysis of the coded presence/absence data by Jaccard's coefficient and transformation into a distance matrix allowed clustering of the populations. Song distances were also depicted through principle coordinates analysis. These representations showed the Jacksonville (Ja) and Meredosia (Me) populations as having the greatest similarity in syllables shared. Whitehall (Wh) clustered close to these two populations in comparison with the Beverly (Bv) population from which only a small pool of syllables was sampled (Table 1). The ability of the Bv sample to represent a sample of syllables comparable in size to the other populations was estimated by randomly selecting one of the three larger populations (Ja) and making five samples of five randomly selected birds each. The number of syllable types in each of the five samples of five birds was then determined and a mean was derived. A mean of 28 (±9.14) syllable types representing 37.8% of the total number of syllable types found in the Ja population resulted. It therefore appears that the Bv sample may not adequately represent the syllable types to be found in that population.

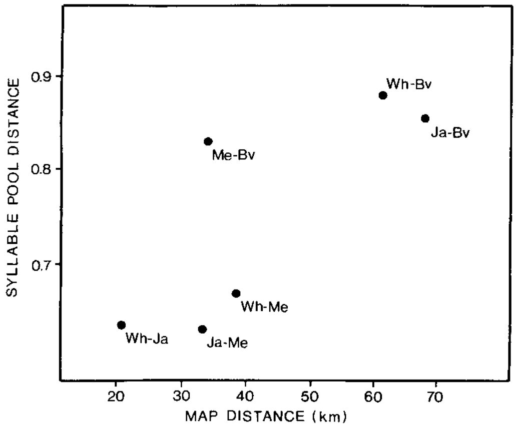

FIGURE 2. Relationship between linear map distance and syllable pool distance separating all four populations.

Figure 2 shows the relationship between syllable pool distance between populations and map distance. The correlation between syllable pool and map distance was determined using the Mantel statistic, as suggested by Dietz (1983), and was significant (Mantel statistic = 203.221, $P < 0.05$). When the effect of the Bv population was removed the three remaining populations clustered similarly, however, the relationship between map and song distance was weakened considerably. The correlation between the map and syllable pool distances of the three remaining populations could not be tested with confidence because of the small number of points. However, the poor relationship is apparent and indicates that the disparity between syllable pool distances and map distances is largely due to Ja being more similar to Me with respect to song distance than to the geographically closer Wh.

DISCUSSION

Examination of presence and absence of syllables of the nest-site song of the Eurasian Tree Sparrow in the syllable pools of various North American populations suggests microgeographic variation in the pattern of distribution of these syllables. Although the number of populations and the number of birds sampled at one of the localities are small, the existence of a large proportion of syllables unique to a single population is still indicative of geographic variation in this type of vocalization. Unique syllables were detected even in the very small Bv sample.

The poor match between syllable pool distance and map distance, due to the Ja sample having a greater song similarity to the Me sample than to the physically closer Wh, may or may not have a causal explanation. Jacksonville and Meredosia are both nearer to the expanding northern edge of the Eurasian Tree Sparrow's North American range. Whitehall is approximately 85 km north of the site of release of the founding birds (St. Louis) in a line drawn north from the center of St. Louis. Jacksonville and Meredosia are 115 and 135 km respectively from St. Louis. These results might be explained if differences existed between populations at the expanding edge of the range and those near the site of release of the original birds, with respect to the number of new syllables introduced into these populations by cultural mutations. However, the small number of populations sampled and the small differences in geographic distances make it difficult to conclude with confidence that proximity to the edge of the population has any effect.

The microgeographic variation indicated in the nest-site song of the Eurasian Tree Sparrow may be related to the system of dispersal demonstrated by this genus. *Passer domesticus,* for example, disperses fewer than 5 km in late summer and autumn of its first year (Fleischer et al. 1984). Once an adult *P. domesticus* begins breeding at a site it continues to nest at this location in succeeding years. Such a dispersal system would preclude panmixia but would still allow limited gene flow and the flow of cultural traits (termed meme flow by Mundinger 1980) from other populations. A continuous pattern of geographic variation of song, as opposed to one with discrete dialects, might be the result of such a system. An alternative system of dispersal to that seen in *Passer* would be that of the European Starling (*Sturnus vulgaris*), a colonial species like the Eurasian Tree and House sparrows. The starling demonstrates a continuous pattern of geographic variation with respect to variants of some "themes," whereas variants of other types of themes are specific to particular colonies (Adret-Hausberger and Güttinger 1984). However, individual starlings tend to breed in their natal colony and may learn their vocalizations there. Because the timing of song learning in Eurasian Tree Sparrows is unknown, it cannot be said whether song learning occurs in the natal colony or the colony to which it disperses. Therefore comparisons to the starling are difficult to make.

Song distances that vary with geographic distances do not appear to be the rule in studies of microgeographic variation in songs of other species. Some species do appear to have a system of dialects with more or less distinct song groupings and relatively clear boundaries between them, for example the much studied White-crowned Sparrow, *Zonotrichia leucophrys* (e.g., Marler and Tamura 1962, 1964; Baker 1975; Baker and Thompson 1985; Baptista 1985), although this claim is disputed (e.g., Jenkins 1985), eastern House Finches, *Carpodacus mexicanus* (Mundinger 1980), and the Rufous-collared Sparrow, *Z. capensis* (Handford and Nottebohm 1976, Handford 1981). The songs of western House Finches show syllable sharing between areas but no apparent boundaries or distinct areas of song similarity, although they do vary with geographic distance (Bitterbaum and Baptista 1979). Sage Sparrow (*Amphispiza belli*) songs however, do not appear to vary closely with geographic distance for as yet undiscovered reasons (Wiens 1982).

Work in progress comparing the songs from the German population with those of the American population may provide more information about the evolutionary forces which have acted on the introduced population and the influence these forces have had upon the geographic variation of the vocalizations in the population. For example, St. Louis and Barlow (in press) implicated genetic drift in reducing genetic variability in the North American population as compared with the German population of the Eurasian Tree Sparrow.

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