A CHRISTMAS COUNT ANALYSIS OF THE FRINGILLIDAE

By Carl E. Bock and Larry W. Lepthien

INTRODUCTION

The purpose of this study is to examine winter patterns of avian abundance and diversity within the family Fringillidae in North America excluding Mexico. We chose to analyze this family for several reasons. First, it contains the largest number of species wintering in the area under consideration, giving a large sample size for measurements of overall abundance and species diversity. Second, a high degree of ecological uniformity exists among North American fringillids in winter because most if not all species feed on seeds. This justifies a comparison of the various species. Finally, it is commonly agreed that the species currently placed in the family (A.O.U. Check-list, 1957) represent at least two very different evolutionary lines (Sushkin, 1925; Mayr, 1946; Beecher, 1953; Tordoff, 1954). One group, the so-called cardueline finches (family Fringillidae *sensu strictu*; Storer, 1971), is generally Holarctic in distribution and probably evolved in the Old World (Mayr, op cit.). The other, the emberizine finches (family Emberizidae; Storer, 1971), apparently evolved in the New World. Cook (1969) has analyzed the breeding season species density of the Fringillidae in North America. On the significance of the species richness pattern for the whole family, he concluded that (p. 77) "since this family is not taxonomically homogeneous, speculations are weak at best."

A number of recent studies have examined geographic patterns of overall avian species density in North America. MacArthur and Wilson (1967), Cook (1969), and Tramer (1974a) computed the number of species hypothetically occurring in large areas based upon information from various check-lists. On a finer scale, Bock and Lepthien (1974) and Tramer (1974b) examined winter patterns revealed by the number of species observed on Christmas Bird Counts (CBC's). In none of these studies was true species diversity calculated, because none included measurement of the relative abundances of species within any given area (see Lloyd and Ghelardi, 1964). Our approach in the present study was to compute individual abundance patterns for all fringillid species using CBC data grouped into 5-degree blocks of latitude and longitude. It was then possible to calculate overall fringillid abundance and species diversity for each block (Figs. 1-3).

The specific objectives of this paper are: (1) to describe winter patterns of abundance and diversity for the family Fringillidae; (2) to compare the cardueline and emberizine groups, with a goal of determining the degree to which they show complementary patterns; and (3) to compare individual species abundance patterns in an ordination with certain climate variables, with the goal of recognizing species that can be grouped not on the basis of taxonomic affinity but because of biogeographical similarities.

METHODS

We have described elsewhere the nature, strengths, and limitations of CBC's, and our methods of computerized data storage, retrieval, and analysis (Bock and Lepthien, 1974). In this case we combined count data by geographic blocks of 5 degrees of latitude and longitude. We computed the mean individuals observed per species per party-hour of effort for all blocks south of 50° N latitude and for the 65 species listed in Appendix I. Counts are rare north of 50° latitude. The sample size was 2,680 counts occurring between 1969-70 and 1971-72, grouped into 51 5-degree blocks (e.g., Fig. 1). We next calulated the total fringillids counted per party-hour for each block and the proportions of that total contributed by the various species. From these data an index of diversity could be calculated for each block as follows:

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

where p_i is the proportion of the ith species and s is the number of species (Peet, 1974). These calculations were made for the family as a whole, and also separately for the cardueline and emberizine groups.

Climatic data for each block were adapted from maps published by the U.S. Department of Agriculture (1941).

RESULTS

Patterns of abundance and species diversity

Figure 1 shows winter abundance and species diversity ($H' \times 10$) for the family Fringillidae based upon Christmas Count data. It is apparent that fringillids were most common in central and especially southwestern regions. Species diversities, however, were relatively uniform, and showed no clear geographic patterns.

Figures 2 and 3 are maps of abundance and diversity of the cardueline and emberizine species, respectively. These groups exhibited more distinctive patterns than did the family as a whole. carduelines were abundant in the north and southwest, whereas diversities were highest in the Rocky Mountains and northeast (Fig. 2). Emberizine finches were most plentiful in the southern half of the study area, except for the Florida peninsula, southern Louisiana, and southeastern Texas (Fig. 3). Species diversities were very nearly complementary to those to the cardueline group.

Similarity of species abundance patterns

Figures 2 and 3 suggest that the cardueline and emberizine groups are to some degree biogeographical counterparts, especially

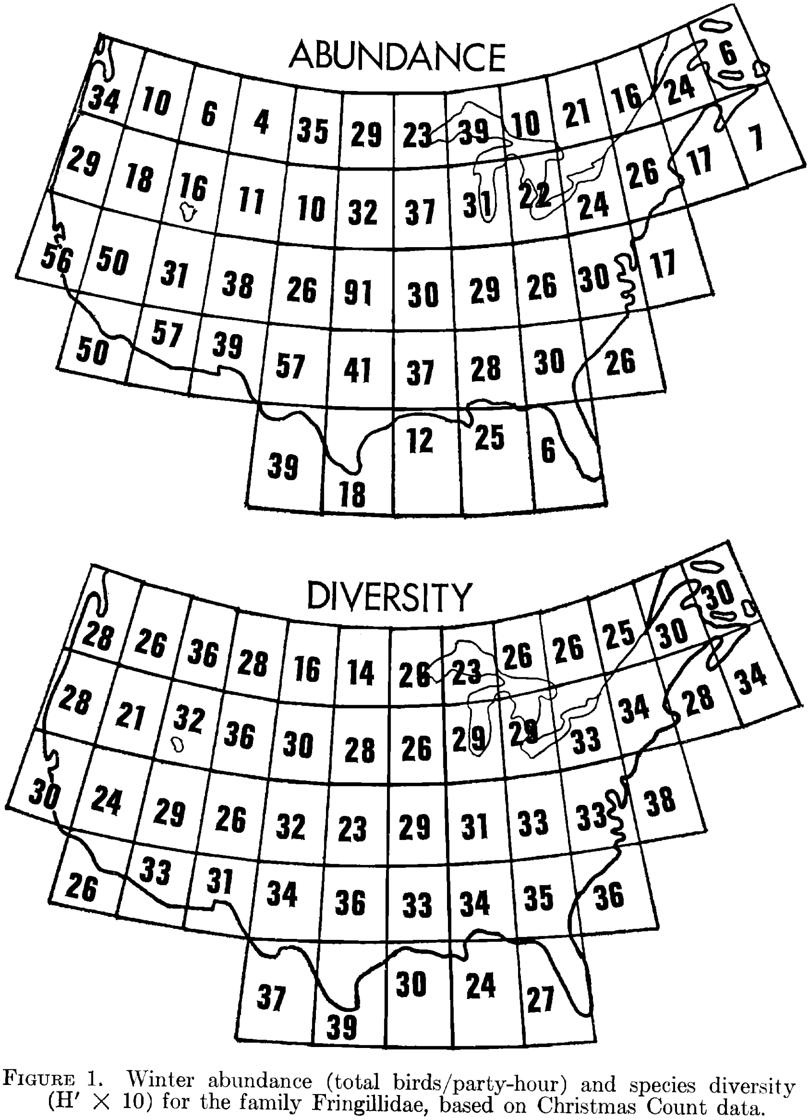

FIGURE 1. Winter abundance (total birds/party-hour) and species diversity (H′ × 10) for the family Fringillidae, based on Christmas Count data.

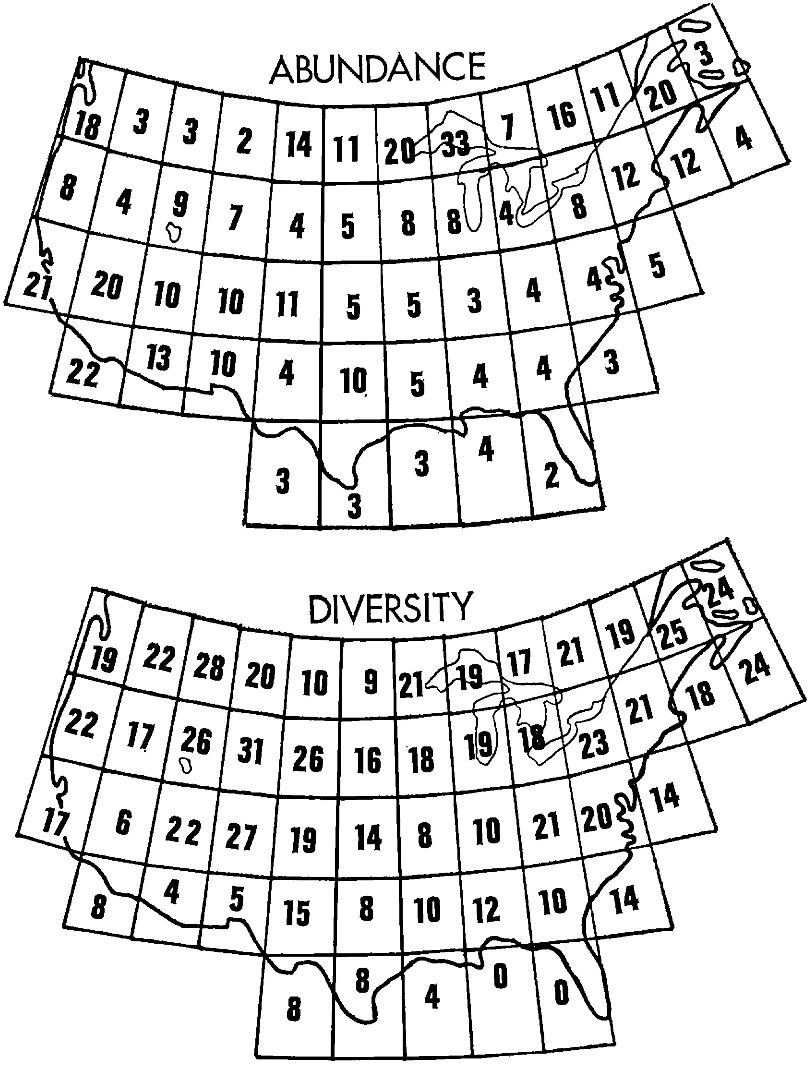

FIGURE 2. Same as Fig. 1 for cardueline taxa only.

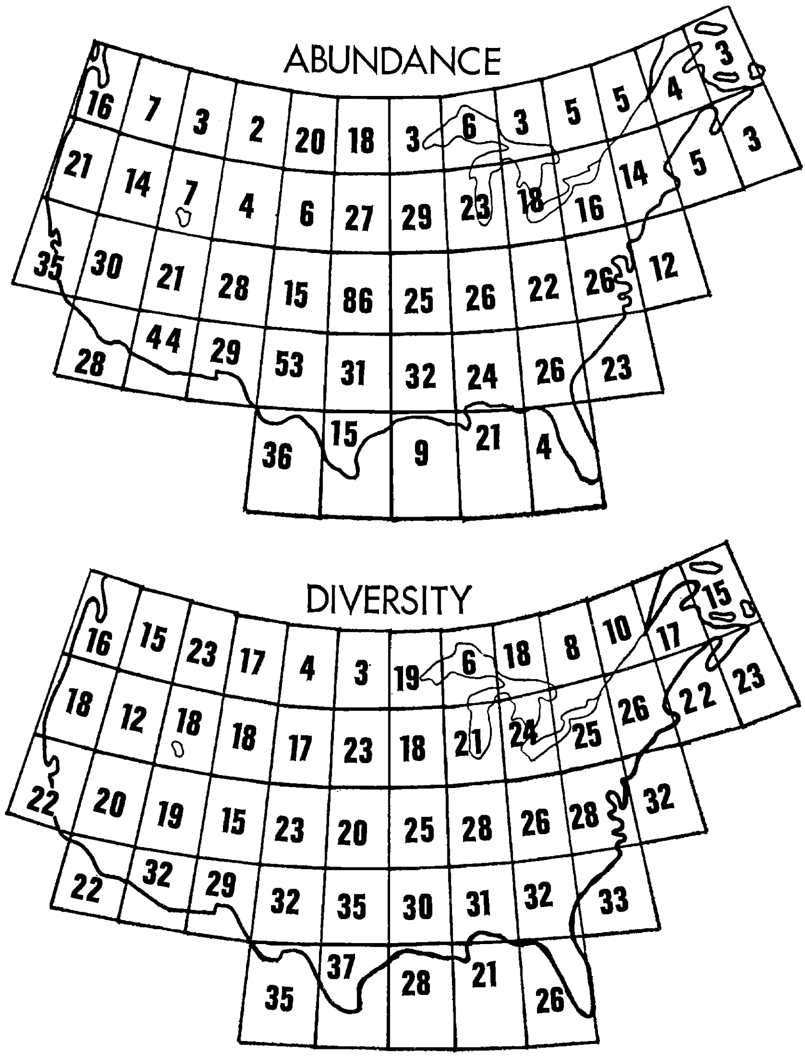

FIGURE 3. Same as Fig. 1 for emberizine taxa only.

with regard to species diversity. To test this idea further, we computed correlation coefficents between the abundance patterns of the 65 species and two major climatic variables, namely average annual temperature and average annual precipitation. Figure 4 is a plot of these data in the form of a two-dimensional ordination. Numbers refer to the species listed in Appendix I; enclosed numbers indicate the cardueline taxa.

Figure 4 shows that the cardueline and emberizine species separate generally along a temperature gradient, but that each group has "invaded" the other's domain in a few conspicuous instances. The cardueline goldfinches (18, 19, 20) and the House Finch (10) are warm climate species in winter. Cold climate emberizines include especially the Tree Sparrow and Snow Bunting. The ubiquitous juncos (44,45) showed essentially no correlation with temperature regime. However, nearly all the emberizines had winter abundance patterns positively correlated with temperature. The major axis separating these species in winter was moisture regime (Fig. 4).

Discussion and Conclusions

The emberizine finches form a winter pattern of species diversity resembling winter species density maps for all bird species (Bock and Lepthien 1974; Tramer, 1974b). That is, they show a southern and southeastern concentration (Fig. 3). Overall species densities also are high well up along the Pacific slope, but the emberizines do not follow this trend as well. Cardueline diversity is *altogether* different from the general avian pattern, being highest in the Rocky Mountain west and in the northeast. Clearly, carduelines are revealing a Holarctic ancestry and a preference for montane and high latitude forests. Although there are some exceptions, ordination of the abundance patterns shows the carduelines to be species of cold climates, whereas the emberizine forms concentrate in winter in warm areas (Fig. 4). These results strongly support the separation of the cardueline and emberizine lines on the basis of biogeographical considerations.

We found very little geographic variation in winter species diversity for the Fringillidae as a whole based on CBC data (Fig. 1). This was somewhat surprising, because Cook (1969) found very striking patterns of high fringillid breeding species densities in the west and very low species numbers in the southeast, based on his check-list analysis. Cook attributed these features to the large amount of topographic relief (= increased habitat variability) in the west and the historical effects of glaciation in the east. Specifically, he suggested that repeated climate deteriorations associated with glacial advances may have caused the loss of warm-climate elements from the avifauna of what is now the southeastern United States. As Tramer (1974a) reported, even if this historical explanation is accurate the question remains as to why subsequent invasions of the area by more north-temperate species have not occurred. For the Fringillidae this is a particular problem, because it is apparent that such species do move into the southeast in winter (Fig. 1). In any event, it would appear that patterns of winter migration do much to "flatten" a map of summer fringillid species diversity, as many species move out of western montane habitats and others move into the relatively warm and productive forests and other habitats of the southeast.

The Fringillidae do show some high concentrations of total numbers, if not diversity, in winter, as they move into the warmer deserts and grasslands of North America (Fig. 1). The suggestion is that these are the areas where seeds are most abundant and most available. Even the cardueline group shows this pattern (Fig. 2). The House Finch is a very aberrant cardueline biogeographically (Fig. 4, number 10), but it is such a common bird that it gives the whole group the appearance of being very abundant in parts of the southwest (Fig. 2).

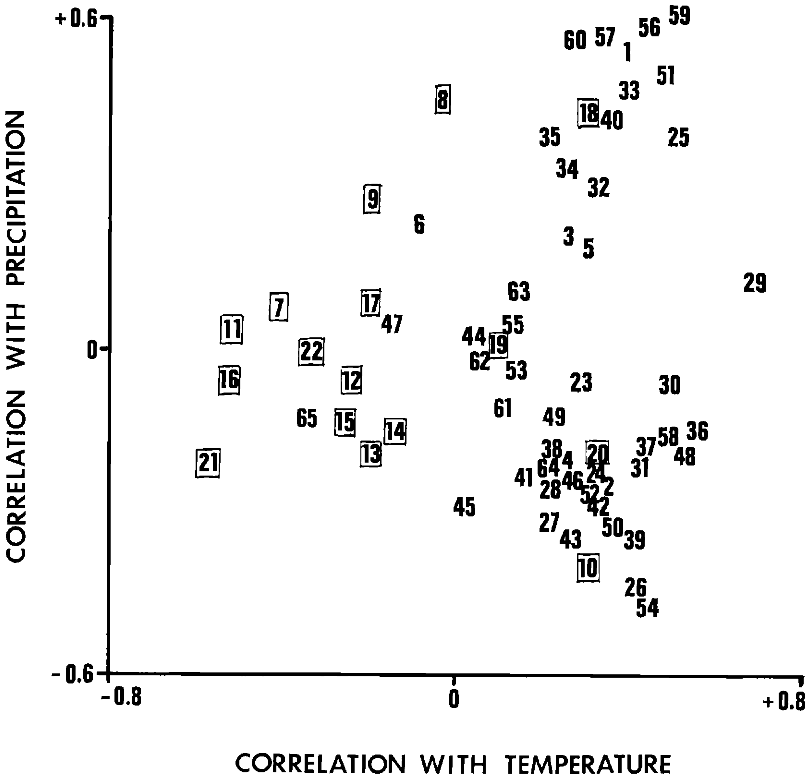

FIGURE 4. Two dimensional ordination of the correlations between winter abundance patterns of 65 fringillid species and mean annual temperature and mean annual precipitation. See Appendix I for a key to the species numbers. Squares indicate the cardueline taxa.

Figure 4 shows one very interesting pattern of fringillid biogeography in addition to a general separation of the cardueline and emberizine subgroups. There appears to be a strong positive association between warm temperature and sensitivity to moisture regime. Most cold-climate species, regardless of taxonomic affinity, appear less restricted in selection for wet vs. dry areas. Among species positively correlated with temperature regime, two very distinct clusters appear. One is a group of species most abundant in moist areas such as the Song Sparrow (60), Swamp Sparrow (59), Field Sparrow (51), and American Goldfinch (18). Even more distinctive is the cluster of species reaching highest abundances in warm-dry areas, including such species as the White-crowned Sparrow (54), Rufous-crowned Sparrow (39), Cassin's Sparrow (41) and Chipping Sparrow (48). Note that very few widespread species show a strong positive correlation with temperature regime but at the same time are abundant in both wet and dry regions. Conspicuous exceptions are the Savannah (29) and Grasshopper sparrows (30); the Savannah Sparrow in particular has a very unusual winter abundance pattern compared with other widespread species.

Figure 4, then, suggests that most warm-climate species are highly adapted either to xeric or to hydric regions, and that these species will not be abundant in both sorts of habitats, *even if they have very wide distributional limits.* If this is a biogeographical principle that proves to have general validity, then detailed ecophysiological and ecological studies should be conducted to determine its causes.

SUMMARY

This paper presents a Christmas Count analysis of abundance and diversity patterns for 65 species of seed-eating birds in the family Fringillidae. Unlike the breeding season, in winter the family as a whole showed little variation in diversity across the United States and southern Canada. It did show high concentrations of numbers in central and southwestern areas. Two major subgroups of the family had complementary patterns of species diversity. The Holarctic cardueline species were concentrated in the Rocky Mountains and the northeast, whereas the New World emberizine forms reached highest diversity in southern regions, especially the southeast. Ordination of individual species abundance patterns against temperature and precipitation variables showed the cardueline and emberizine groups separating along a temperature gradient. In addition, it revealed a strong positive correlation between warm temperature and sensitivity to moisture regime, such that very few species selecting areas with warm temperatures were common both in wet and dry regions, even if they were widely distributed.

ACKNOWLEDGMENTS

We are grateful to the University of Colorado Computer Center and Taximetrics Laboratory for their help with the computing and statistical portions of this work. This project was supported by grant GB 36860 from the National Science Foundation.

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Appendix I.

List of species included in this study of the family Fringillidae. Numbers refer to data presented in Figure 4.

1. Cardinal (*Cardinalis cardinalis*)
2. Pyrrhuloxia (*Pyrrhuloxia sinuata*)
3. Indigo Bunting (*Passerina cyanea*)
4. Lazuli Bunting (*P. amoena*)
5. Painted Bunting (*P. ciris*)
6. Dickcissel (*Spiza americana*)
7. Evening Grosbeak (*Hesperiphona vespertina*)*
8. Purple Finch (*Carpodacus purpureus*)*
9. Cassin's Finch (*C. cassinii*)*
10. House Finch (*C. mexicanus*)*
11. Pine Grosbeak (*Pinicola enucleator*)*
12. Gray-crowned Rosy Finch (*Leucosticte tephrocotis*)*
13. Black Rosy Finch (*L. atrata*)*
14. Brown-capped Rosy Finch (*L. australis*)*
15. Hoary Redpoll (*Acanthis hornemanni*)*
16. Common Redpoll (*A. flammea*)*
17. Pine Siskin (*Spinus pinus*)*
18. American Goldfinch (*S. tristis*)*
19. Lesser Goldfinch (*S. psaltria*)*
20. Lawrence's Goldfinch (*S. lawrencei*)*
21. Red Crossbill (*Loxia curvirostra*)*
22. White-winged Crossbill (*L. leucoptera*)*
23. Olive Sparrow (*Arremenops rufivirgata*)
24. Green-tailed Towhee (*Chlorura chlorura*)
25. Rufous-sided Towhee (*Pipilo erythrophthalmus*)
26. Brown Towhee (*P. fuscus*)
27. Albert's Towhee (*P. aberti*)
28. Lark Bunting (*Calamospiza melanocorys*)
29. Savannah Sparrow (*Passerculus sandwichensis*)
30. Grasshopper Sparrow (*Ammodramus savannarum*)
31. Baird's Sparrow (*A. bairdii*)
32. LeConte's Sparrow (*Ammospiza leconteii*)
33. Henslow's Sparrow (*Ammodramus henslowii*)
34. Sharp-tailed Sparrow (*Ammospiza caudacuta*)
35. Seaside Sparrow (*A. maritima*)
36. Vesper Sparrow (*Pooecetes gramineus*)
37. Lark Sparrow (*Chondestes grammacus*)
38. Rufous-winged Sparrow (*Aimophila carpalis*)
39. Rufous-crowned Sparrow (*A. ruficeps*)
40. Bachman's Sparrow (*A. aestivalis*)
41. Cassin's Sparrow (*A. cassinii*)
42. Black-throated Sparrow (*Amphispiza bilineata*)
43. Sage Sparrow (*A. belli*)
44. Dark-eyed Junco (*Junco hyemalis*)
45. Gray-headed Junco (*J. caniceps*)
46. Yellow-eyed Junco (*J. phaenotus*)
47. Tree Sparrow (*Spizella arborea*)
48. Chipping Sparrow (*S. passerina*)
49. Clay-colored Sparrow (*S. pallida*)
50. Brewer's Sparrow (*S. breweri*)
51. Field Sparrow (*S. pusilla*)
52. Black-chinned Sparrow (*S. atrogularis*)
53. Harris' Sparrow (*Zonotrichia querula*)
54. White-crowned Sparrow (*Z. leucophrys*)
55. Golden-crowned Sparrow (*Z. atricapilla*)
56. White-throated Sparrow (*Z. albicollis*)
57. Fox Sparrow (*Passerella iliaca*)
58. Lincoln's Sparrow (*Melospiza lincolnii*)
59. Swamp Sparrow (*M. georgiana*)
60. Song Sparrow (*M. melodia*)
61. McGown's Longspur (*Calcarius mecownii*)
62. Lapland Longspur (*C. lapponicus*)
63. Smith's Longspur (*C. pictus*)
64. Chestnut-collared Longspur (*C. ornatus*)
65. Snow Bunting (*Plectrophenax nivalis*)

*species in the cardueline subgroup.