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NOTE

ASSESSING AVIAN RICHNESS IN REMNANT WETLANDS: TOWARDS AN IMPROVED METHODOLOGY

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Abstract: Because the North American Breeding Bird Survey provides inadequate coverage of wetland habitat, the Wetland Breeding Bird Survey was recently established in Ohio, USA. This program relies on volunteers to conduct 3 counts at each monitored wetland. Currently, all counts are conducted during the morning. Under the premise that volunteer participation could be increased by allowing evening counts, we evaluated the potential for modifying the methodology. We evaluated the sampling efficiency of all 3-count combinations of morning and evening counts using data collected at 14 wetlands. Estimates of overall species richness decreased with increasing numbers of evening counts. However, this pattern did not hold when analyses were restricted to wetland-dependent species or those of conservation concern. Our findings suggest that it would be reasonable to permit evening counts, particularly if the data are to be used to monitor wetland-dependent species and those of concern.

Key Words: avian diversity, evening surveys, point counts, sampling efficiency, species richness

INTRODUCTION

Widespread destruction of wetlands is still underway throughout much of the United States (Dahl et al. 1991). In Ohio, 90% of the original wetland habitat has been eliminated (Dahl et al. 1991). The remaining wetlands in Ohio and surrounding Great Lakes region provide nesting and migratory-stopover habitat for over 250 bird species (Peterjohn et al. 1987), but many of these species have been in decline (Herkert 1995). Concern over these species has been heightened by the recent Supreme Court decision invalidating the so-called migratory bird rule (U.S. Supreme Court 2001), which had been used to protect isolated wetlands under the Clean Water Act.

Our ability to devise effective management plans will depend on reliable monitoring data for wetland-dependent birds (Ribic et al. 1999). Although many routes of the long-standing North American Breeding Bird Survey (BBS) include wetland habitat, the BBS was not designed specifically to survey wetland birds (Herkert 1995), particularly inconspicuous species such as rails (*Rallus* spp.), bitterns (American bittern, *Botaurus lentiginosus* Rackett; least bittern, *Ixobrychus exilis* Gmelin), and the common moorhen (*Gallinula chloropus* Linnaeus) (Ribic et al. 1999). In response to the need for specialized programs to complement the BBS, two programs were recently established: the Wetland Breeding Bird Survey (WBBS) in Ohio (Andres 1991) and the Marsh Monitoring Program (MMP) throughout the Great Lakes region (Weeber et al. 1999, Bird Studies Canada and Environment Canada 2001). Both programs use volunteers to conduct surveys, but WBBS protocol currently follows the standard practice (Ralph et al. 1993) of restricting surveys to the morning. The MMP protocol, however, requires evening surveys, with the intent of increasing volunteer participation. With a view toward increasing volunteer participation in the WBBS program, we evaluated the potential for modifying the protocol to

allow evening surveys (counts). We compared estimates of species richness based on various combinations of morning and evening counts (Ribic et al. 1999).

METHODS

The study was conducted at 14 wetlands (sites) located within adjacent physiographic regions, the Glaciated Allegheny Plateau and the Central Lowland Till Plains (Brockman 1998) in Ohio. Six sites were surveyed in 1998 and eight in 1999. A list of candidate sites was generated using topographic maps, a GIS database (Ohio Department of Natural Resources 2000), and personal communications. Because area and habitat heterogenity affect species richness (e.g., Swift et al. 1984, Craig and Beal 1992), all sites were required to meet the following criteria. They were small (10–16 ha) natural wetlands, comprising a combination of shallow-water and shrub-scrub vegetation and open water, with forest bounding part or all of the periphery.

Point-count (Ralph et al. 1993, 1995) and call-response (playback) methods (Gibbs and Melvin 1997, Ribic et al. 1999) were used to survey birds in each wetland (for reviews of methodological strengths and weaknesses, see Ralph et al. (1995) and Ribic et al. (1999)). An array of points was established at each site prior to the breeding season. The number of points (9–14) varied depending on the size of the wetland and the presence of visual obstructions. The area around each point was a full circle unless the point was located near the edge of the wetland. The radius (75–100 m) varied depending on visual obstructions. Birds were counted for 7 min at each point. During the middle 3 min, a tape player was used to play back vocalizations of Virginia rail (*Rallus limicola* Vieillot), sora (*Porzana carolina* Linnaeus), common moorhen, pied-billed grebe (*Podiceps nigricollis* Linnaeus), and least bittern. Surveys were conducted by traveling from point to point in opposite directions during successive surveys. One or two sites were surveyed each day. To avoid order effect, the order of site visitation was randomized (except during May 1998). In 1999, to minimize automobile travel, the order was based on simple randomization after first specifying a random order of visitation across three geographic clusters of sites. Each site was surveyed in the morning (0530–1000) and evening (1730–2130), and surveys were completed either on the same day or during successive days (i.e., during the evening and the following morning). At each site, four pairs of morning and evening surveys were conducted during May–June (5 May–21 June 1998, 10 May–20 June 1999), with the exception of one missing morning survey at one site. Dates correspond with the timing of the three (morning) surveys conducted by volunteers in the WBBS program.

Data analyses were performed using SigmaStat (1997) routines. Analyses were performed to compare estimates of species richness based on all possible three-count combinations of morning and evening counts (i.e., three morning, two morning and one evening, one morning and two evening, and three evening counts). Initially, all species were included, then species were classified by guild: wetland dependent (35 species), wetland associated (36 species) and wetland independent (63 species) (Brown and Smith 1998). Finally, species were included if they were judged to be of conservation concern. This judgment was based on whether a species declined during either 1966–1999 or 1980–1999, or if rare, whether the data were deficient. The declining-species determination was based on trend analysis of BBS data for Ohio, U.S. Fish and Wildlife Service Region 3, and four geographic regions (Ohio Hills, Lexington Plain, Till Plain, and Allegheny Plateau) (Sauer et al. 2000). The rare-species and deficient-data criteria were met if (1) the species was low in abundance ($<$1.0 individuals/route), (2) the sample was small (based on $<$14 routes), (3) the results were imprecise (a 3% per year change could not have been detected); and if the subinterval trends were inconsistent (i.e., trends for 1966–1979 and 1980–1999 were different with at least one negative trend) (Sauer et al. 2000). Finally, we refined our analysis of species of conservation concern by sequentially excluding from the dataset: (1) very common species (those detected at 12 or more of the 14 sites), (2) species detected at nine or more sites, and (3) species detected at six or more sites.

For each analysis, we initially performed two-way repeated-measures analysis of variance to evaluate effects of count combination (treatment), year, and treatment-by-year interaction on estimates of species richness. These analyses revealed no year effects (all Ps > 0.84) or year-by-treatment interactions (all Ps > 0.25) but did reveal violations of assumptions of normality, equal variance, or both. Therefore, to compare estimates of species richness based on three counts across all possible morning-evening combinations, we used Friedman's nonparametric one-way repeated-measures ''ANOVA'' (hereafter, Friedman's test). Analyses were based on means generated by random resampling (code written in C++ Borland®) from four morning and four evening surveys conducted at each site. For example, to generate a mean estimate of species richness for the combination of two morning counts and one evening count, we randomly sampled without replacement (10,000 iterations) the observed values for two of the four morning counts and one of the four evening counts. Dunn's test (on ranks) was

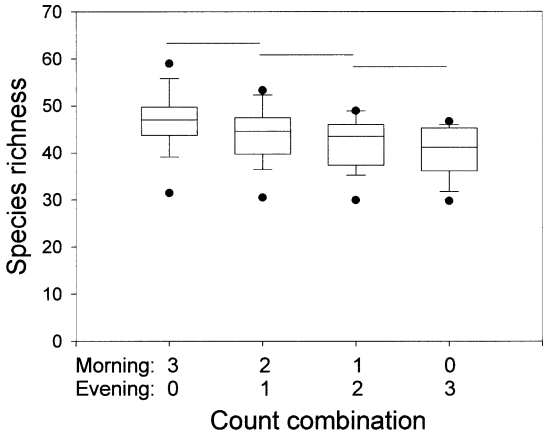

Figure 1. Average observed richness of wetland bird species in Ohio, 1998–1999, for each of the possible combinations of morning and evening counts. Horizontal lines within the boxes represent the median, boxes the interquartile range, error bars the 95% confidence interval, and points the extreme values. Horizontal lines above the boxes connect categories not significantly different from each other ($P > 0.05$ based on Dunn's pairwise comparisons). The count combinations (*x*-axis) represent all possible 3-count permutations of morning and evening counts (e.g., the combination labeled morning: 2, evening: 1 represents data collected during all permutations of 2 morning counts combined with 1 evening count).

used to perform all possible pairwise comparisons, with the critical *á*–level set at 0.05.

RESULTS

Significant heterogeneity emerged in the relative sampling efficiency across all possible three-count combinations of morning and evening counts ($P < 0.001$; Figure 1), with the inclusion of increasing numbers of evening counts tending to reduce estimates of species richness. This pattern, however, could have been driven by specific guilds. Analysis of this possibility revealed no heterogeneity across count combinations for wetland-dependent (Figure 2a, $P = 0.65$) or wetland-associated species (Figure 2b, $P = 0.077$), although the latter result should not be ignored. For wetland-independent species, however, heterogeneity emerged ($P < 0.001$; Figure 2c), with the inclusion of increasing numbers of evening counts tending to reduce estimates of species richness (Figure 2c).

For species of concern, heterogeneity in sampling efficiency emerged for the 89-species category only (Figure 3a, $P = 0.003$; results for other categories: Figure 3b, $P = 0.49$; Figure 3c, $P = 0.45$; Figure 3d, $P = 0.65$). Thus, inclusion of evening counts in a three-count survey tended to reduce estimates of species richness for species of concern but only when common species were included in the analysis.

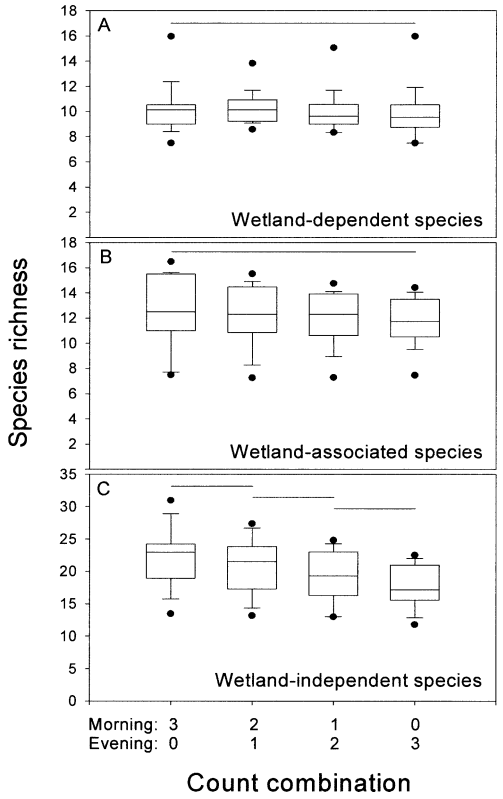

Figure 2. Average observed richness of wetland bird species in Ohio, 1998–1999, for each of the possible combinations of morning and evening counts (see Figure 1 legend for detailed explanation of *x*-axis labeling). The panels represent three guilds: wetland-dependent (A), wetland-associated (B), and wetland-independent (C). Horizontal lines within the boxes represent the median, boxes the interquartile range, error bars the 95% confidence interval, and points the extreme values. Horizontal lines above the boxes connect categories not significantly different from each other ($P > 0.05$ based on Dunn's pairwise comparisons).

DISCUSSION

Our initial analysis suggested that any substitution of evening counts for morning counts would reduce the number of species detected (Figure 1). This finding seems to suggest that the WBBS protocol should remain unchanged because the current method (morning surveys only) maximizes relative sampling efficiency. However, this conclusion does not stand up to the scrutiny of follow-up analyses. Based on these analyses, we conclude that it may be reasonable to permit evening counts if the main purpose of WBBS is to monitor wetland-dependent species and/or species of conservation concern, especially if volunteer participation would increase as a consequence. Beyond offering the provisional recommendation that evening surveys be permitted in the WBBS, we encourage managers of other monitoring programs to evaluate whether their protocols could be similarly modified.

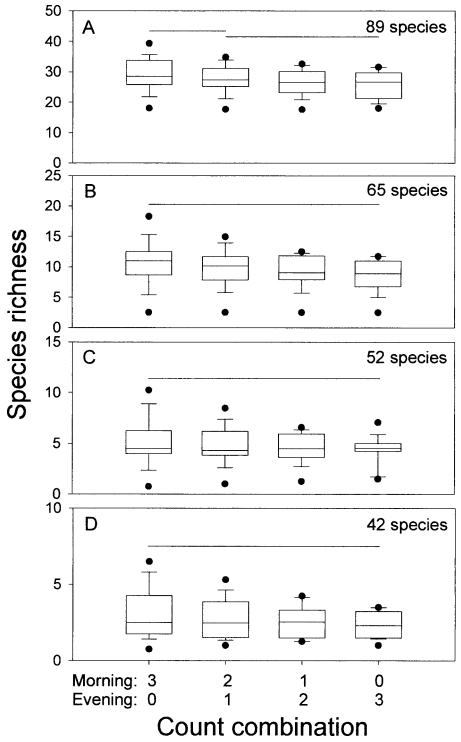

Figure 3. Average observed richness of wetland bird species in Ohio, 1998–1999, for each of the possible combinations of morning and evening counts (see Figure 1 legend for detailed explanation of *x*-axis labeling). Panels represent species fitting four increasingly stringent definitions of conservation concern: (A) species (89) were included if known to be in decline or if rare and if the data were deficient (see methods for details), (B) species (65) were included if they met the above criteria and were detected at <12 of 14 wetlands, (C) species (52) were included if the met the original criteria and were detected at <9 of 14 wetlands, and (D) species (42) were included if the met the original criteria and were detected at <6 of the 14 wetlands. Horizontal lines within the boxes represent the median, boxes the interquartile range, error bars the 95% confidence interval, and points the extreme values. Horizontal lines above the boxes connect categories not significantly different from each other ($P > 0.05$ based on Dunn's pairwise comparisons).

This study represents a modest contribution to the broader goal of developing a standardized methodology for monitoring wetland birds. Several crucial issues regarding design of wetland-bird surveys remain to be addressed. A statistically valid sampling scheme has not yet been developed because the relationship between observed (point-count and call response data) and absolute abundance is unknown (detection probabilities are unknown). The relationships between estimates of species richness and other indices of diversity (e.g., Shannon, Simpson, Brillouin) are also unknown (for a detailed review of these and other issues see Ribic et al. (1999)).

We suggest, contrary to the conventional approach (Ralph et al. 1993), that the sampling efficiency of evening surveys may be just as high as that of morning surveys, in the limited context of estimating species richness of wetland-dependent birds. Future work should evaluate sampling efficiency of various combinations of morning and evening surveys for estimation of other indices of the diversity of wetland birds.

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