Research Journal of Biological Sciences 5 (11): 713-721, 2010
ISSN: 1815-8846

Measuring Associations Between *Granivorous grassland* Bird Species and Between the Bird Species and Winter Habitat in Northwestern Mexico

[1]G. Jose Hugo Martinez, [2]Christian Wehenkel, [1]Martin E. Pereda Solis, [3]Jose Javier Corral-Rivas, [1]Federico Rosales Alferez and [1]Hector Herrera Casio
[1]Facultad de Medicina Veterinaria y Zootecnia, [2]Instituto de Silvicultura e Industria de la Madera, [3]Facultad de Ciencias Forestales, Universidad Juarez del Estado de Durango, 34000 Dgo, Mexico

Abstract: Researchers evaluated the usefulness of two statistical methods, not used in ornithological studies to measure associations between granivorous grassland bird species and between the same species and seven different vegetation characteristics. The study was carried out in winter in the region of Cuchillas de la Zarca in Northwestern Mexico. Kendall's coefficient showed little consistency in the determinations and only 2.19% of the associations between species were significant ($p<0.05$). *Ammodramus bairdii*, *Ammodramus savannarum* and *Sturnella magna* were positively and significantly associated as were *Aimophila cassini* and *Passerculus sandwichensis*. Gregorius's method was more consistent in determining the association (A) between *Granivorous grassland* birds (α) and vegetation features (β) with 48.9% of the estimations being significant. A total of 12 species were associated with shrub height, 7 with grass height, 19 with herbaceous height, 13 with shrub cover, 16 with grass cover, 18 with herbaceous cover and 14 with other types of cover such as superficial decomposing organic material. Researchers conclude that these statistical methods may be of greater utility in ornithological studies than their historical absence from this branch of biology indicates.

Key words: Kendall coefficient, Permutation test, vegetation attributes, chihuahuan desert, *Aimophila cassini*, Mexico

INTRODUCTION

The principal objective of avian ecological studies is to measure and understand the roles of habitat characteristics (Johnson, 2007) and the quantitative determination of features related to population parameters of individual species and the community is the basis of successful conservation programmes (Sherry and Holmes, 1995; Morrison *et al*., 2006). Populations of grassland birds have decreased more than those of any other group of birds (Sauer *et al*., 2008) as a result of changes in land use (Askins *et al*., 2007).

Recent studies have focused on the relationships involving vegetation characteristics and the presence and distribution of grassland birds (Davis, 2001), reproductive success (Christoferson and Morrison, 2001), density and abundance of birds, size and shape of the habitat patch (Davis, 2004), territory requirements (Vickery *et al*., 1994; Johnson and Igl, 2001), agricultural activity (Vickery *et al*., 2004), grazing pressure (Fondell and Ball, 2004), grassland management practices (Madden *et al*., 2000; Nocera *et al*., 2007) and the availability of insects while nesting (Poulin and Lefebvre, 1997). Jones (2001) carried out a complete literature search of habitat selection studies in avian ecology. Likewise, Johnson (2007) reviewed methods of measuring habitat quality. Both researchers identified the need to be able to interpret findings by applying statistical methods appropriate to the objectives of the investigation (Sutherland *et al*., 2005; Morrison *et al*., 2006).

To this end, some investigators have proposed the use of unconventional statistical methods to estimate associations between species and habitat in forestry studies of Wehenkel *et al*. (2005) and Gregorius (1998)'s method and between insect species (Legendre, 2005) however, these techniques have not been used in avian ecology studies until now.

The objectives of the present study were therefore to estimate associations between *Granivorous grassland* bird species and between the species and vegetation during winter in Northwestern Mexico by use of statistical analyses not typically used in ornithological studies.

MATERIALS AND METHODS

Study site: The study area is located in the Grasslands Priority Conservation Area (GPCA) known as Cuchillas de la Zarca (CEC and TNC, 2005) (Fig. 1), which is part of the Chihuahuan desert. The area lies in Southern Chihuahua

Corresponding Author: Martin E. Pereda Solis, Apartado Postal 291, Durango, 34000 Dgo, Mexico

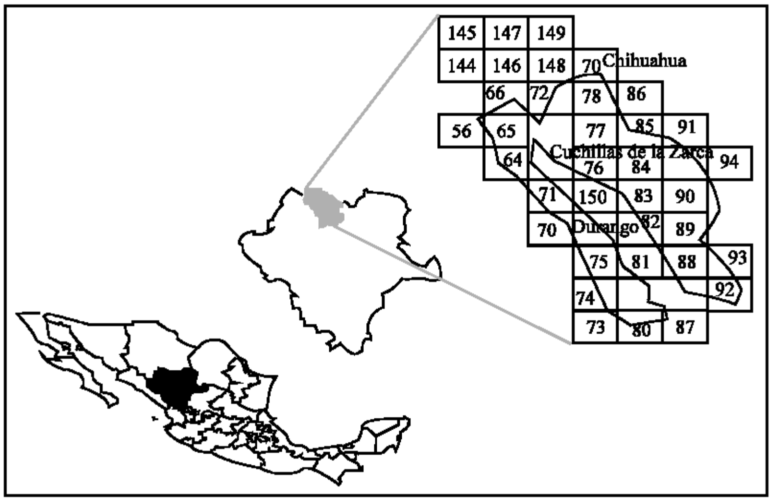

Fig. 1: Location of the Cuchillas de la Zarca grasslands priority conservation area

and Northern Durango, Mexico and covers an area of 6,297 km^2 between geographic coordinates 105°04' 30.86"W and 24°41' 41.28"N and 104°57' 07.48"W and 25°27' 04.24"N. Vegetation in the site is composed of dry thicket (91%) and natural grassland 9%. The thicket consists of the following genera: Larrea, Prosopis, Acacia, Ephedra, Nolina, Opuntia, Juniperus and Quercus and the herbaceous stratum include Bouteloa, Aristida, Buchloe, Andropogon, Muhlenbergia, Sporobolus, Heteropogon and Pleuraphis.

Study design: Researchers used a GIS to construct a grid of 16-18 km^2 blocks covering the entire surface area of the GPCA. There were selected sixteen blocks in which native grassland vegetation occurs and which also contain >5 km of paths and marked points at every 500 m within the blocks. There were selected three transects at random for monitoring birds and vegetation within each block (Panjabi *et al*., 2007).

Bird monitoring: Researchers followed the methodology proposed by Panjabi *et al*. (2007), i.e., two observers who were trained to recognize grasslands birds walked in pairs along transects of 1 km from the first three randomized points in each block in which walking paths were available and used GPS for navigation.

The observers used 8×42 binoculars and a laser distance meter to record species and numbers of birds observed and the perpendicular distance to the transect of birds found individually or in groups. The bird census was carried out between January 20 and February 15, 2009 from 08:00-12:00 h every day. The observers focused on granivorous species and counted the number of individuals of each species per block monitored.

Vegetation measurements: Immediately after completing the bird censuses, the observers turned round and walked the transect in the opposite direction to measure the vegetation. The observers stopped every 100 m to measure ground cover within 5 m and shrub cover within 50 m with a GPS unit. Measurements included percentage cover of grasses, herbaceous plants, bare ground and other cover as well as grass, herbaceous and shrub height (Panjabi *et al*., 2010).

Measurement of associations between bird species: Operational concepts of species association refer to groups of species that are significantly found together without this necessarily implying any positive biological interaction among the species. Bird species association was measured by Kendall's coefficient of concordance (W), a non-parametric statistic. This is a normalization of the Friedman test statistic and can be used to measure the agreement among several (p) judges that assess a given set of n objects.

Depending on the field of application, the judges can be variables, characters, etc., although in the present study, they are species. The W and the Friedman test vary only in the formulation of their respective null hypothesis. In the Friedman test, the null hypothesis is that there is no real difference among the n objects (sites). Kendall's test focuses on the p judges. If the null hypothesis of the Friedman test is true, this indicates that the judges have produced rankings that are independent of one another.

This is the null hypothesis of Kendall's test (Legendre, 2005). Instead of using the usual row-marginal sums of ranks R_i (Siegel and Castellan Jr., 1988) there used the close relationship between Spearman's correlation coefficient r_S and W to compute Kendall's W statistic: W can be calculated directly from the mean ($\bar{r}$) of the pairwise Spearman correlations r_S by use of the following relationship (Siegel and Castellan Jr., 1988; Zar, 1999; Legendre, 2005):

$$W = \frac{(p-1)\bar{r}+1}{p} \quad (1)$$

where, p is the number of variables (or judges) among which Spearman's correlation coefficients are computed. For two variables (or judges) only, W is simply a linear transformation of r_S: $W = (r_S + 1)/2$ and in this case, a permutation test of W for two variables is the exact equivalent of a permutation test of r_S for the same variables. Equation 1 shows that judges are only considered concordant if their Spearman correlations are positive.

Two judges that give perfectly opposite ranks to a set of objects have a Spearman correlation of -1, hence W = 0 (no agreement) for these two judges; this is the lower boundary of the coefficient of concordance. For two judges only, $r_S = 0$ gives W = 0.5 which indicates a greater or lesser degree of unanimity among the various responses. If the test statistic r_S is and therefore, W is 1 then all the survey respondents have been unanimous (Legendre, 2005).

Measuring associations between bird species and vegetation: Researchers applied the association (A) developed by Gregorius (1998) wherein, α and β represented bird species and vegetation, respectively. The relationship is denoted as $A(\alpha|\beta)$ and can reach two extreme values: complete association of α with β where, $A(\alpha|\beta) = 1$ and complete absence of association where, $A(\alpha|\beta) = 0$.

The wording α is associated with β can also be read as α depends on is determined by or is a function of β. This measure is analogous to the estimation of the regression coefficient and is asymmetric in the sense that $A(\alpha|\beta) \neq A(\beta|\alpha)$. Formally:

$$A(\beta|\alpha) = \sum_{b \in C_\beta} A(\beta = b|\alpha).\ \pi(\beta = b)$$

$$A(\beta = b|\alpha) = \frac{1}{2}\sum_{a \in C\alpha} \left|\pi(\alpha = a|\beta = b) - \pi(\alpha = a|\beta \neq b)\right| \quad (2)$$

Where, Π is the relative frequency.

Statistical analysis: The sampling strategy suggests the use of permutation tests to assess the possibility that the observed associations (r_S, W, A) may have resulted from random assignment. Significance probabilities (p values) are given in terms of the proportion of permutations for which the association measures (r_S, W, A) exceed the observed value. On this basis, observed W, r_S and A values are to be interpreted as significantly large or significantly small if the pertinent significance probability is small (<0.05) or high (>0.95), respectively. In both cases, forces other than random forces must be assumed to be involved in generation of the observed associations (Manly, 1997; Legendre, 2005; Wehenkel *et al*., 2005). Researchers used PROC UNIVARIATE and PROC GLM from SAS® for parametric statistical analyses.

RESULTS AND DISCUSSION

Bird monitoring: Researchers monitored birds along 96 transects each of 1 km (6 per 16 blocks) and registered 16,635 individual birds from 31 families, 63 genera and 79 different species of which 26 (32.9%; 7,257 individuals) were *Granivorous grassland* birds. The species found and the relative abundances of each are shown in Table 1.

Vegetation measurements: Table 2 shows the results of vegetation characteristics on the region.

Association between bird species: Of the 684 associations between 26 species of granivorous birds estimated by use of Kendall's coefficient only 15 were significant (Table 3).

Table 1: Abundance of granivorous bird species in Cuchillas de la Zarca in winter 2009

Species	Alpha code[1]	n	Average[2]	SE[2]	Abundance (%)
Aimophila botterii	AIMBOT	1	0.06	0.06	0.013
Aimophila cassinii	AIMCAS	7	0.43	0.18	0.096
Aimophila ruficeps	AIMRUF	7	0.43	0.32	0.096
Ammodramus bairdii	AMMBAI	49	3.05	0.52	0.675
Ammodramus savannarum	AMMSAV	80	5.00	0.98	1.102
Amphispiza bilineata	AMPBIL	119	7.43	3.87	1.639
Anthus spragueii	ANTSPR	40	2.50	0.63	0.551
Calamospiza melanocorys	CALMEL	3	0.18	0.13	0.041
Calcarius ornatus	CALORN	936	58.50	30.88	12.897
Callipepla squamata	CALSQU	126	7.87	3.84	1.736
Carpodacus mexicanus	CARMEX	11	0.68	0.28	0.151
Chondestes grammacus	CHOGRA	326	20.37	11.83	4.492
Eremophila alpestris	EREALP	6	0.37	0.27	0.082
Melospiza lincolnii	MELLIN	9	0.56	0.28	0.124
Molothrus ater	MOLATE	42	2.62	2.62	0.578
Passerculus sandwichensis	PASSAN	417	20.06	6.45	5.746
Pipilo fuscus	PIPFUS	49	3.06	0.85	0.675
Pooecetes gramineus	POOGRA	1607	100.43	22.32	22.144
Spizella breweri	SPIBRE	692	43.25	12.71	9.535
Spizella pallida	SPIPAL	148	9.25	4.18	2.039
Spizella passerina	SPIPAS	1871	116.93	20.64	25.782
Sturnella magna	STUMAG	149	9.31	1.61	2.053
Sturnella neglecta	STUNEG	22	1.37	0.49	0.303
Zenaida asiatica	ZENASI	57	3.56	2.18	0.785
Zenaida macroura	ZENMAC	481	30.06	5.96	6.628
Zonotrichia leucophrys	ZONLEU	2	0.12	0.08	0.027

Six-letter alpha codes, international nomenclature, AOU calculated using PROC UNIVARIATE from SAS®

Table 2: Mean vegetation characteristics per block in Cuchillas de la Zarca in winter 2009

	Height			Cover (%)			
Blocks	Shrub (m)	Grass (cm)	Herb (cm)	Shrub	Grass	Herb	Other
56	1.540^{b}	10.70^{g}	7.76^{g,h}	2.635^{g,h}	49.75^{f}	9.13^{e-g}	19.83^{a-c}
64	0.796f	28.96^{a,b}	19.40^{a,b}	3.502^{f-h}	66.25^{a-d}	10.11^{d-g}	14.23^{c-g}
65	0.911^{e,f}	10.46^{g}	9.50^{f-h}	9.592^{c,d}	62.20^{c-e}	12.21^{b-d}	14.11^{d-g}
66	2.025^{a}	26.16^{a-d}	11.88^{d-f}	5.595^{e-g}	60.58^{d,e}	9.91^{d-g}	16.23^{c-f}
71	1.545^{b}	23.23^{c-e}	18.35^{a-c}	7.262^{d,e}	65.08^{a-e}	14.91^{b}	10.43^{g,h}
76	1.541^{b}	21.90^{d,e}	12.48^{d-f}	4.900^{e-g}	70.91^{a}	9.25^{e-g}	8.30^{h}
77	1.538^{b}	15.20^{f,g}	15.50^{b-d}	11.155^{c}	62.58^{b-e}	12.83^{b-d}	11.91^{e-h}
83	0.750^{f}	26.10^{a-d}	15.71^{b-d}	2.970^{f-h}	63.21^{b-e}	11.06^{c-g}	13.05^{d-h}
88	0.988^{e,f}	23.71^{b-e}	14.38^{d,e}	6.042^{e,f}	59.83^{d,e}	11.91^{c-e}	17.50^{c-e}
92	1.138^{c-e}	10.83^{g}	10.71^{e-g}	15.950^{b}	43.00^{g}	13.16^{b,c}	24.83^{a}
93	1.005^{d-f}	19.90^{e,f}	20.73^{a}	19.017^{a}	36.38^{h}	18.83^{a}	23.11^{a,b}
144	1.056^{d-f}	13.20^{g}	6.43^{h}	1.295^{h}	66.08^{a-d}	6.10^{h}	15.03^{c-g}
145	1.315^{b-d}	31.25^{a}	14.85^{c,d}	2.855^{f-h}	68.68^{a-c}	8.25^{f-h}	10.48^{g,h}
146	1.565^{b}	13.55^{g}	8.98^{f-h}	3.362^{f-h}	50.76^{f}	8.46^{f-h}	18.18^{b-d}
147	1.176^{c-e}	27.68^{a-c}	13.96^{d,e}	2.483^{g,h}	69.85^{a,b}	8.10^{g,h}	11.20^{f-h}
150	1.416^{b,c}	19.75^{e,f}	18.73^{a-c}	7.183^{d,e}	57.66^{e}	11.21^{c-f}	14.31^{c-g}

One-way ANOVA, completely random blocks model, PROC GLM, SAS®; Mean values followed by different letters are significantly different at $\alpha = 0.05$, Duncan's test of multiple comparisons

Table 3: Association (W) between granivorous birds in the region of Cuchillas de la Zarca, winter 2009 and its p value with 5,000 permutations

Species	Association (W)	p-value
Ammbai/Sturnag	0.498	0.020
Ammbai/Passan	0.446	0.040
Ammbai/Ammsav	0.456	0.030
Spibre/Chogra	0.565	0.010
Spibre/Poogra	0.596	0.008
Pipfus/Spipas	0.445	0.040
Pipfus/Zenmac	0.593	0.008
Pipfus/Antspr	0.461	0.030
Pipfus/Ampbil	0.578	0.010
Aimcas/Passan	0.443	0.040
Aimcas/Spipal	0.468	0.040
Spipas/Calsqu	0.478	0.030
Chogra/Carmex	0.600	0.010
Antspr/Ampbil	0.618	0.007
Ampbil/Molate	0.448	0.020

Associations at $p \leq 0.05$ are significant and at $p \leq 0.01$, highly significant

Association between granivorous bird species and vegetation features: The significant results of the 182 associations (A) that there were tested between granivorous bird species and vegetation characteristics are shown in Table 4.

Bird monitoring: The Cuchillas de la Zarca GPCA is important habitat for migratory grassland birds (CEC and TNC, 2005) as 20 of the 26 species under study in all of northwestern Mexico during the winter of 2009 were present. Levandoski *et al*. (2008) ranked Cuchillas 2nd out of nine sites with respect to number of species and density of individuals in a long term study of Chihuahuan desert birds.

The most abundant species in the region were *Spizella passerina* (25.7%), *Pooecetes gramineus* (22.1%) and *Calcarius ornatus* (12.9%) which is not surprising in light of the social behavior of these birds which gather in large flocks (Sedgwick, 2004; Dunne, 2006). Furthermore, *P. gramineus* was one of the most widely distributed of the study species in Cuchillas de la Zarca and was present in all blocks. This species may be so, widely distributed because it tolerates habitats with high densities of herbs and diverse shrubs (Wiens *et al*., 1985). In contrast, the species present at the lowest densities were: *Aimophila botterii* (n = 1) which is a secretive bird that needs high grasses (Jones and Bock, 2005), a vegetation characteristic not present in the study region; *Calamospiza melanocorys* (n = 3), a gregarious bird during winter but that concentrates in great flocks to forage where food availability is good (Shane, 2000) and *Eremophila alpestris* (n = 6), a species that inhabits dry, open zones with short, low-density grasses (Dinkins *et al*., 2001), the latter habitat was present in the study region. Both of the latter species were found to be abundant in a study by Manzano-Fisher *et al*. (1999) in Northwestern Chihuahua, Mexico.

Vegetation measurements: The estimated vegetation characteristics varied between sampled blocks. The average vegetative cover for the study area was 85.6%, average grass cover was 59.5±2.46%; grass height 20.16±1.75 cm; herbaceous cover, 10.9±0.76%; herbaceous height, 13.7±1.07 cm; shrub cover, 6.61±1.26%; shrub height, 1.26±0.08 m and other cover, 15.1±1.15% (such as organic material deposited on the ground which represents a food source, protection and/or perches for birds; Askins, 1994).

The differences in the mean valuescorroborate the findings of Block *et al*. (1987), who reported differences between 31 of 49 estimated variables which can be explained by temporal and spatial variations in the habitat that generate conditions favoured by

Table 4: Association (A) of granivorous bird species (α) with vegetation characteristics (β) in Cuchillas de la Zarca, winter 2009

	Vegetation characteristics (β)						
Species (α)	Shr ht	Gra ht	Her ht	Shr cov1	Gra cov	Her cov	Oth cov
Aimbot	0.663	0.000	0.253	0.522	0.882	0.383	0.546
Aimcas	0.195	0.161	0.176	0.336	0.188	0.189	0.311
Aimruf	0.663**	0.000	0.253	0.193	0.168	0.097	0.546**
Ammbai	0.134	0.283**	0.321**	0.132	0.098*	0.313**	0.252**
Ammsav	0.139**	0.000	0.275**	0.193**	0.006	0.295**	0.232**
Ampbil	0.375**	0.000	0.384**	0.283**	0.538**	0.456**	0.316**
Antspr	0.013	0.168**	0.249**	0.097	0.183**	0.294**	0.079
Calmel	0.329	0.525**	0.414	0.272	0.549*	0.284	0.546
Calorn	0.218**	0.252**	0.192**	0.380*	0.099*	0.342**	0.352**
Calsqu	0.069	0.000	0.276**	0.107*	0.025	0.143**	0.317**
Carmex	0.117	0.000	0.293*	0.522	0.337**	0.436**	0.001
Chogra	0.167**	0.522	0.292**	0.530**	0.031	0.388**	0.559**
Erealp	0.329	0.022	0.414*	0.189	0.549**	0.284	0.213
Mellin	0.338*	0.000	0.253	0.330*	0.118	0.161	0.213
Molate	0.666**	0.000	0.254*	0.525**	0.119*	0.385**	0.549**
Passan	0.006	0.034	0.093**	0.228*	0.072**	0.062*	0.032
Pipfus	0.194**	0.205*	0.300**	0.114	0.230**	0.375**	0.159*
Poogra	0.033*	0.000	0.105**	0.079**	0.057**	0.056**	0.075**
Spibre	0.054**	0.205**	0.300**	0.008	0.095**	0.086**	0.013
Spipal	0.034	0.000	0.120**	0.205**	0.162**	0.402**	0.226**
Spipas	0.031*	0.193	0.132**	0.142**	0.063**	0.093**	0.013
Stumag	0.064	0.107*	0.180**	0.050	0.073**	0.198**	0.155**
Stuneg	0.065	0.000	0.066	0.161	0.027	0.020	0.182
Zenasi	0.110	0.000	0.559**	0.252**	0.084	0.480**	0.387**
Zenmac	0.073**	0.067	0.077**	0.069**	0.116**	0.282**	0.102**
Zonleu	0.163	0.000	0.253	0.022	0.118	0.117	0.546

Vegetation measurements were made at sites where shrub cover was ≤15%; *p≤0.05; **p≤0.01

birds (Cody, 1985) in a region subjected to strong pressure in relation to land use change due to agriculture and cattle grazing.

Associations between granivorous grassland birds: Of the 15 significant positive Associations (A) found (Table 3), the most interesting are those between *Ammodramus bairdii* and *Sturnella magna* and between *Passerculus sandwichensis* and *Ammodramus savannarum* as these species when abundant within their breeding range are considered indicators of healthy mixed grasslands (Davis, 2004). These associations are even more significant in that it may be possible to assume that the presence of one implies the presence of the other especially when one of the species is difficult to find and observe. In this sense, the associations between *Aimophila cassinii* and both *Spizella pallida* and *P. sandwichensis* have important implications. The former species is a secretive bird that requires dense grass close to shrubs (Bock and Sharf, 1994) and it was identified only seven times in the surveys whereas the latter two species form large flocks, respond to the production of grass and herbaceous seeds on their wintering grounds are easily observed (Ginter and Desmond, 2005) and were registered 148 and 417 times, respectively.

Researchers also found a positive association between *Anthus spragueii* and *Amphispiza bilineata* (Table 3). The former is a solitary species that prefers open areas with relatively low grass density and is recognized as a grassland indicator species within its breeding range (Davis *et al*., 2006; Koper *et al*., 2009) while the latter prefers more dense, shrubby vegetation, mostly *Larrea tridentata* (Dunne, 2006). The other associations were species that occur in shrubby and herbaceous vegetation and therefore estimation of W has biological sense.

Association (A) between bird species and vegetation features: In general, the values of A fluctuated between 0.00 and 0.880 although, the arithmetic mean was ≅0.200 for all bird species and all vegetation features. Various studies have described and distinguished the preferences of grassland birds on the basis of distinct habitat resources, under different conditions (Herkert, 1994; Fletcher and Koford, 2002). However, no studies have been carried out to measure the association between grassland species and features of winter vegetation in Mexico by using statistical analyses not conventionally used in ornithological studies. Discussion of the present results and comparison with similar investigations are therefore limited. Overall, 70% of the 26 bird species monitored were significantly associated (A) with herbaceous height followed by 69% with herbaceous cover, grass cover (61.5%), other cover (53.8%) and shrub height (46%). In a similar study carried out in winter in Texas, Igl and Ballard (1999) found the highest density of grassland birds in sites with grass and bushes rather than those with trees. In general, the findings regarding height of vegetation revealed 9.1% lower association (A) with bird species than those involving cover.

In particular, *Aimophila botterii* and *A. cassinii* were not significantly associated with any vegetation feature (with the former having a value of A>0.800 for grass cover, totally independently from herbaceous height and cover). However, Jones and Bock (2005) observed a positive correlation between grass height and cover for the species in Arizona. In comparison, significant A-values were obtained for *Aimophila ruficeps* and shrub height and other cover; a finding that describes the preference of this species for chaparral environment with few open areas (Thorngate and Parsons, 2005).

Ammodramus bairdii was strongly associated with herb height and cover and to a lesser degree but significantly so with grass height and other cover types. These findings are consistent with those of Davis *et al.* (1999), who observed correlations between the abundance of this species and moderate cover of organic material and height of vegetation >25 and <100 cm. In Manitoba, De Smet and Conrad (1991) found the highest density of *A. bairdii* in mixed grass with herbaceous cover between 10 and 50%.

Random associations with height and grass cover were observed for *Ammodramus savannarum* as well as moderate yet significant, correlation with herbaceous height and cover. This was in contrast to the findings of Ruth (2008), who reported that this species prefers tall, relatively ungrazed grasses and shows little tolerance to bushes. However, the latter study was carried out during the breeding season of the species.

Calamospiza melanocorys, populations of which have been decreasing annually is common and abundant during winter in dry, shrubby grasslands of Durango and Chihuahua and it is easy to find them alongside roads (Shane, 2000). In the present study, there was a significant association between this species and grass height and cover. The highest significant value of A was that for *Molothrus ater* and shrub height (0.666) with a similar result for shrub and other cover; findings that are consistent with those of Sharp and Kus (2006), Jensen and Cully (2005) and Hauber and Russo (2000), who reported that this bird was more abundant in sites closer to woody vegetation which offer more sites for perching. The A values for *Spizella passerina* and *Pooecetes gramineus* (the most abundant species in this study) and the vegetation variables were low but significant as a result of the high frequency of occurrence and wide distribution of the species which did not display any marked preference for a particular type of vegetation structure or cover. *Anthus spragueii* was significantly, although only slightly associated with grass and herbaceous height and cover but totally independently of shrub height these results are consistent with those of Davis (2004) who found that the species prefers open grasslands and that their abundance is related to the size of the grass patch and area of grass cover. The highest value of A for grass cover and herbaceous height corresponded to *Eremophila alpestris* in contrast to the observations of Robinson and Moore (2005), who associated this species with bare ground.

The majority of associations (A) calculated for the 26 species of granivorous grassland birds in this study can be explained on the basis of their behavior and habitat selection in other sites and seasons. Researchers can also conclude on the basis of the results that granivorous grassland species use other resources such as seeds of herbaceous plants and bushes to satisfy their winter habitat requirements for food and protection. Researchers therefore, obtained positive biologically significant results in this first attempt to use Kendall's coefficient of concordance (W) and Gregorius's method (A) to measure associations between bird species and certain habitat characteristics while recognizing that there are several factors that influence winter habitat use in the arid grasslands of northern Mexico (Macías-Duarte *et al.*, 2009).

CONCLUSION

Researchers calculated associations between granivorous grassland bird species and between vegetation and the species of granivorous grassland birds wintering in Northwest Mexico by using Kendall's coefficient of concordance and obtained significant values of W = 0.618 where, 0<W<1 for species with very specific grassland or scrub habitat requirements. This method could therefore be used to estimate such associations within this field of research. However, additional studies are required in order to standardize use of the method and to confirm its reliability in avian ecology. Researchers were able to measure the association between granivorous grassland bird species and certain vegetation characteristics by calculating A (Gregorius, 1998) and found significant results in which $A(\alpha|\beta)\leq 0.666$ where, $0<A\ (\alpha|\beta)<1$. Different bird species were associated to varying degrees with the habitat where they were observed and recorded during monitoring and the method generally, provided consistent results which could be explained by studies at different times and places and by use of other methods to estimate similar associations. As with the Kendall coefficient, this method warrants further application in avian research as it has already been used successfully in other fields of science such as forest genetics.

ACKNOWLEDGEMENTS

Researchers thank the Rocky Mountain Bird Observatory in Fort Collins, Colorado, USA for financial and technical support and the National Commission for the Knowledge and Use of Biodiversity, Mexico (CONABIO) for the loan of a GIS unit.

REFERENCES

Askins, R.A., 1994. History of Grasslands in the Northeastern United States: Implications for Bird Conservation. In: Grasslands of Northeastern North America: Ecology and Conservation of Native and Agricultural Landscapes, Vickery, P.D. and P.W. Dunwiddle (Eds.). Mass Audubon Soc., USA., pp: 119-136.

Askins, R.A., F. Chavez-Ramirez, B.C. Dale, C.A. Haas, J.R. Herkert, F.L. Knopf and P.D. Vickery, 2007. Conservation of grassland birds in North America understanding ecological processes in different regions. Ornitholog. Monographs, 64: 92-92.

Block, W.M., K.A. With and M.L. Morrison, 1987. On measuring bird habitat: Influence of observer variability and sample size. The Condor, 89: 241-251.

Bock, C.E. and W.C. Sharf, 1994. A nesting population of Cassin's sparrows in the sandhills of Nebraska. J. Field Ornithol., 65: 472-475.

CEC. and TNC, 2005. North american central grasslands priority conservation areas: Technical report and documentation. Commission for Environmental Cooperation and The Nature Conservancy. Montreal, Quebec, pp: 36.

Christoferson, L.L. and M.L. Morrison, 2001. Integrating methods to determine breeding and nesting status of 3 Western songbirds. Wildlife Soc. Bull., 29: 688-696.

Cody, M.L., 1985. Habitat Selection in Birds. 1st Edn., Academic Press, Inc., Harcourt Brace Jovanovich, Orlando, Florida, ISBN13: 978-0-12-178081-4.

Davis, C.A., 2001. Abundance and habitat associations of birds wintering in the Platte River Valley, Nebraska. Great Plains Res., 11: 233-248.

Davis, S.K., 2004. Area sensitivity in grassland passerines: Effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in Southern Saskatchewan. The Auk, 121: 1130-1145.

Davis, S.K., D.C. Duncan and M. Skeel, 1999. Distribution and habitat associations of three endemic grassland songbirds in Southern Saskatchewan. Wilson Bull., 111: 389-396.

Davis, S.K., R.M. Brigham, T.L. Shaffer and P.C. James, 2006. Mixed-grass prairie passerines exhibit weak and variable responses to patch size. The Auk, 123: 807-821.

De Smet, K.D. and M.P. Conrad, 1991. Management and research needs for Baird's Sparrows and other grassland species in Manitoba. Proceedings of the 2nd Endangered Species and Prairie Conservation Workshop, (ESPC'91), Alberta, pp: 83-86.

Dinkins, M.F., A.L. Zimmerman, J.A. Dechant, B.D. Parkin and D.H. Johnson *et al*., 2001. Effects of management practices on grassland birds: Horned Lark. Northern Prairie Wildlife Research Center, Jamestown, ND, USA. Northern Prairie Wildlife Research Center. http://www.npwrc.usgs.gov/resource/literatr/gras bird/hola/hola.htm.

Dunne, P., 2006. Pete Dunne's Essential Field Guide Companion. Houghton Mifflin Harcourt, Boston, New York, USA.

Fletcher, R.J. Jr. and R.R. Koford, 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. J. Wild Manage., 66: 1011-1022.

Fondell, T.F. and I.J. Ball, 2004. Density and success of bird nests relative to grazing on western Montana grasslands. Biolog. Conservat., 117: 203-213.

Ginter, D.L. and M.J. Desmond, 2005. Influence of foraging and roosting behavior on home-range size and movement of savannah sparrows wintering in South Texas. Wilson Bull., 117: 63-71.

Gregorius, H.R., 1998. Measuring associations between two traits. Acta Biotheoretica, 46: 89-98.

Hauber, M.E. and S.A. Russo, 2000. Perch proximity correlates with higher rates of cowbird parasitism of ground nesting song sparrows. Wilson Bull., 112: 150-153.

Herkert, J.R., 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecolog. Applic., 4: 461-471.

Igl, L.D. and B.M. Ballard, 1999. Habitat associations of migrating and overwintering grassland birds in Southern Texas. The Condor, 101: 771-782.

Jensen, E.W. and J.F. Cully, 2005. Density-dependent habitat selection by brown-headed cowbirds (*Molothrus ater*) in tallgrass prairie. Oecology, 142: 136-149.

Johnson, D.H. and L.D. Igl, 2001. Area requirements of grassland birds: A regional perspective. The Auk, 118: 24-34.

Johnson, M.D., 2007. Measuring habitat quality: A review. The Condor, 109: 489-504.

Jones, J., 2001. Habitat selection studies in avian ecology: A critical review. The Auk, 118: 557-562.

Jones, Z.F. and C.E. Bock, 2005. The botteri's sparrow and exotic Arizona grasslands: An ecological trap or habitat regained?. The Condor, 107: 731-741.

Koper, N., D.J. Walker and J. Champagne, 2009. Nonlinear effects of distance to habitat edge on Sprague's pipits in Southern Alberta, Canada. Landscape Ecol., 24: 1287-1297.

Legendre, P., 2005. Species associations: The Kendall coefficient of concordance revisited. J. Agric. Biolog. Environ. Statist., 10: 226-245.

Levandoski, G., A. Panjabi and R. Sparks, 2008. Wintering bird inventory and monitoring in priority conservation areas in Chihuahuan desert grasslands in Mexico: 2008 results. Rocky mountain bird observatory. Brighton, CO, Final Technical Report I-MXPLAT-TNC-08, Mexico, pp: 88.

Macías-Duarte, A., A.B. Montoya, C.E. Mendez, J.R. Rodríguez, W. Hunt and P. Krannitz, 2009. Factors influencing habitat use by migratory grassland birds in the State of Chihuahua, Mexico. The Auk 126: 896-905.

Madden, E.M., R.K. Murphy, A.J. Hansen and L. Murray, 2000. Models for guiding management of prairie bird habitat in Northwestern North Dakota. Am. Midland Naturalist, 144: 377-392.

Manly, B.F.G., 1997. Randomization, Bootstrap and Monte Carlo Methods in Biology. 2nd Edn., Chapman and Hall, London.

Manzano-Fisher, P., R. List and G. Ceballos, 1999. Grassland birds on praire-dog towns in Northwestern Chihuahua, Mexico. Studies Avian Ecol., 19: 263-271.

Morrison, L.M., B. Marcot and W. Mannan, 2006. Wildlife Habitat Relationships, Concepts and Applications. 3rd Edn., Island Press, USA.

Nocera, J.J., G. Forbes and R. Milton, 2007. Habitat relationships of three grassland breeding bird species: Broadscale comparisons and hayfield management implications. Avian Conservat. Ecol., 2: 7-7.

Panjabi, A., G. Levandoski and R. Sparks, 2007. Wintering bird inventory and monitoring in priority conservation areas in Chihuahuan desert grasslands in Mexico: 2007 pilot results. Rocky Mountain Bird Observatory, Brighton, CO. Final Technical Report I-MXPLAT-TNC07-02.

Panjabi, A., G. Levandoski and R. Sparks, 2010. Wintering bird density and habitat use in Chihuahuan desert grasslands. Rocky Mountain Bird Observatory, Brighton, CO, RMBO Technical Report I-MXPLAT-08-02, pp: 118.

Poulin, B. and G. Lefebvre, 1997. Estimation of arthropods available to birds: Effect of trapping technique, prey distribution and bird diet. J. Field Ornithol., 68: 426-442.

Robinson, D. and R. Moore, 2005. Range, abundance and habitat associations of streaked horned lark (*Eremophila alpestris strigata*) during winter. Department of Fisheries and Wildlife and Oak Creek Lab of Biology, 104 Nash Hall, Oregon State University, Corvallis, OR 97331.

Ruth, J., 2008. Distribution and abundance of breeding Arizona grasshopper sparrow (*Ammodramus savannarum ammolegus*) in the Southwestern United States: Past, present and future. Stud. Avian Biol., 37: 113-124.

Sauer, J.R., J.E. Hines and J. Fallon, 2008. The North American breeding bird survey, results and analysis 1966-2007, version 5.15.2008. US Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland.

Sedgwick, J.A., 2004. Chestnut-collared longspur (*Calcarius ornatus*): A technical conservation assessment. USDA Forest Service, Rocky Mountain Region. http://www.fs.fed.us/r2/projects/scp/assessments/chestnutcollaredlongspur.pdf.

Shane, T.G., 2000. Lark Bunting (*Calamospiza melanocorys*). In: The Birds of North America, Poole, A. and F. Gill (Edn.), The Birds of North America, Inc., Philadelphia, PA., pp: 542.

Sharp, B.L. and B.E. Kus, 2006. Factors influencing the incidence of cowbird parasitism of least bell's Vireo. J. Wild Manage., 70: 682-690.

Sherry, T.W. and R.T. Holmes, 1995. Summer Versus Winter Limitation of Populations: Issues and Evidence, In: Ecology and Management of Neotropical Migratory Birds, Martin, Y.M. and D. Finch (Eds.), Oxford University Press, Oxford, UK., pp: 85-120.

Siegel, S. and N.J. Castellan Jr., 1988. Nonparametric Statistics for the Behavioral Sciences. 2nd Edn., McGraw-Hill, New York, USA.

Sutherland, J.W., I. Newton and R. Green, 2005. Bird Ecology and Conservation. A Handbook of Techniques. Oxford University Press Inc., New York, USA.

Thorngate, N. and M. Parsons, 2005. Rufous-crowned sparrow (*Aimophila ruficeps*). In the Coastal Scrub and Chaparral Bird Conservation Plan: A Strategy for Protecting and Managing Coastal Scrub and Chaparral Habitats and Associated Birds in California. California Partners in Flight.

Vickery, J.A., R.B. Bradbury, I.G. Henderson, M.A. Eaton and P.V. Grice, 2004. The role of agri-environment schemes and farm management practices in reversing the decline of farmland birds in England. Biolog. Conservat., 119: 19-39.

Vickery, P.D., M.L. Hunter Jr. and S.M. Melvin, 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservat. Biol., 8: 1087-1097.

Wehenkel, C., F. Bergmann and H.R. Gregorius, 2005. Is there a trade-off between species diversity and genetic diversity in forest tree communities. Plant Ecol., 185: 151-161.

Wiens, J.A., J.T. Rotenberry and B. Van Horne, 1985. Territory size variation in shrubsteppe birds. The Auk, 102: 500-505.

Zar, H.J., 1999. Biostatistical Analisysis. 4th Edn., Prentice Hall, USA.