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Does the reproductive season account for more records of birds in a marked seasonal climate landscape in the state of São Paulo, Brazil?

Vagner Cavarzere[1,2,3]

ABSTRACT

Investigators have reported that birds from temperate regions are more detectable during their breeding seasons, which should be used to adequately survey avifaunas. In the state of São Paulo, southeastern Brazil, the rainiest months of the year are usually associated with a peak in the reproduction of birds. To test the hypothesis that birds are equally detectable throughout the year, I conducted transect counts of birds in a predominantly open Cerrado *landscape in São Paulo during 2005 and 2006. There was no significant difference in the number of species or individuals between breeding (rainy) and nonbreeding (dry) seasons; 24% of the species with > 50 contacts was likely to be recorded more often in a particular season. Unlike temperate regions, where vocal behavior plays an important role in detections of birds during and after reproductive seasons, my results suggest that* Cerrado *birds may be evenly detected throughout the year.*

Key-Words: Breeding season; Neotropical region; Sampling period; Seasonal abundance; Seasonal climate; Seasonal species richness.

INTRODUCTION

Differences in hourly detections as well as seasonal variations of birds have been exhaustively investigated in temperate regions (Howell *et al.,* 2004; Link & Sauer, 2007; Rehm & Baldassarre, 2007; Wightman *et al.,* 2007; Brewster & Simons, 2009; Cimprich, 2009 and references therein). Neotropical habitats, however, have not been the scope of these evaluations (*e.g.,* Hutto *et al.,* 1986; Blake, 1992; Lynch, 1995; Esquivel & Peris, 2008). It has been proposed that counts of birds can vary seasonally according to forest type and functional groups, whereas a trend in decreasing detections can be observed throughout the day (Herzog *et al.,* 2003; Blendinger, 2005; Isacch *et al.,* 2006; Brandolin *et al.,* 2007; Antunes, 2008; Volpato *et al.,* 2009). Although there is increasing literature on variations of bird detections, a clear consensus on when and how to survey Neotropical birds is still far from being achieved.

Surveying birds during breeding seasons is one of the most widespread rules of thumb among ornithologists as seasons have been suggested to influence the detection and density estimates of birds (Maron *et al.,* 2005; Link & Sauer, 2007; Wightman *et al.,* 2007). This typical approach has been poorly demonstrated in Neotropical habitats (Blendinger, 2005; Brandolin *et al.,* 2007; Antunes, 2008; Volpato *et al.,*

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2009); in the *Cerrado,* for example, a tropical savanna with seasonal rainfall, only hourly counts of birds have been examined (Cavarzere & Moraes, 2010). Determining successful protocols for surveying birds is a priority as many studies use counting techniques with no *a priori* tests regarding method efficiency or habitat type.

Here I wished to investigate seasonal variations in the detection of birds in a predominantly open *Cerrado* landscape in southeastern Brazil using transect counts. Because the reproductive season of birds in the state of São Paulo is usually associated with the rainiest months of the year, I tested if birds, measured as number of species and individually, are evenly detected during breeding (rainy) and nonbreeding (dry) seasons.

METHODS

Study area

I conducted this research at the 321 ha Jardim Botânico Municipal de Bauru (hereafter JB) and at the Universidade Estadual Paulista campus (hereafter UNESP) located in the municipality of Bauru (22°20'S, 49°00'W) in the central-western region of the state of São Paulo, southeastern Brazil. The study areas, close to the urban perimeter (Fig. 1), are located within the *Cerrado* and include mature *cerradão* woodland (closed-canopy dry forest), seasonal semideciduous forest and alluvial forest (Cavassan *et al.,* 1984). UNESP has anthropogenic environments such as orchards and *Brachiaria* sp. grass fields. There are also lakes and regenerating early stage secondary growth, all reachable by roads or routes. The climate is Cwag in Koeppen's classification, typically seasonal with drier (April-September) and wetter months (October-March; Cavassan *et al.,* 1984). For a detailed description of the study areas, refer to Cavarzere *et al.* (2011).

Bird counts

I established two transect lines (1.5 km ± 0.3; mean ± SD) 1.5 km apart running across all environments at the study areas, but predominantly ranging

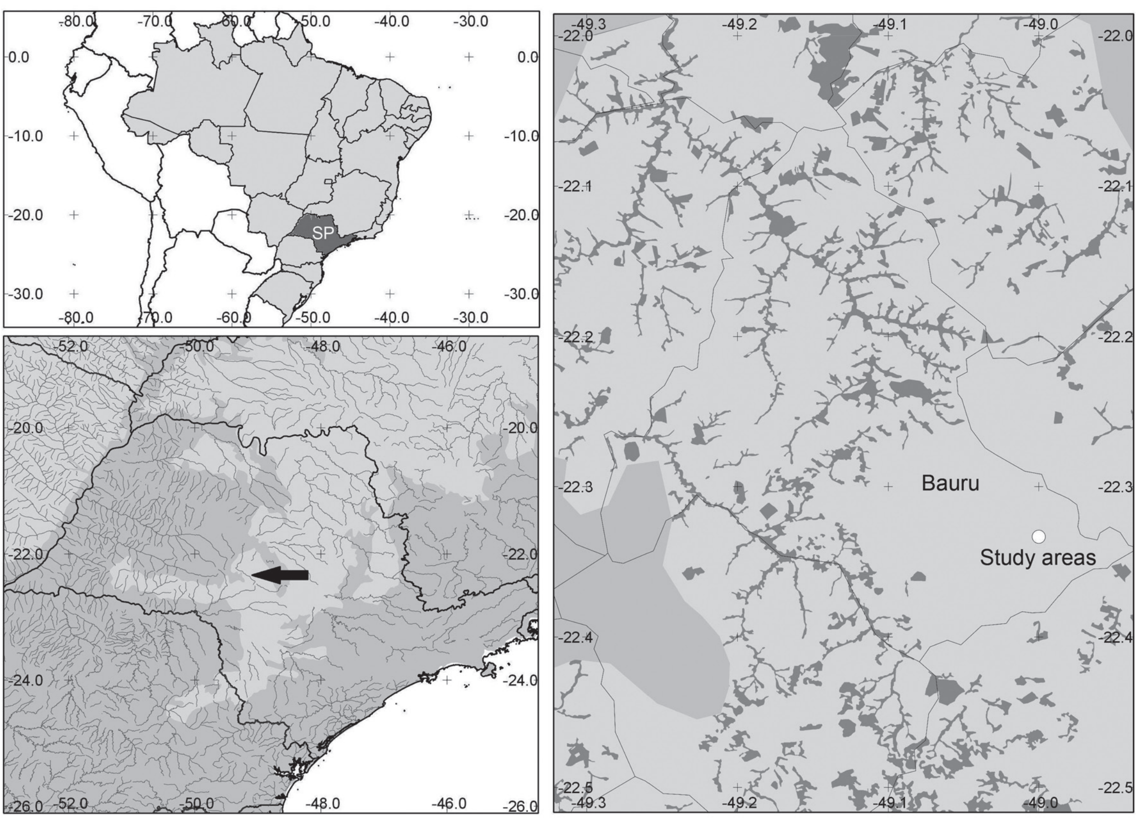

FIGURE 1: Location (white circle) where bird surveys were carried out in the municipality of Bauru (black arrow), state of São Paulo, southeastern Brazil. Shades of gray represent the original *Cerrado* vegetation cover (light hue) and the Atlantic forest (intermediate hue); dark gray hues indicate the present-day distribution of *Cerrado* remnant vegetation.

over open habitats. I walked slowly at constant speed (5 km/h) and recorded every bird seen or heard within an estimated 100 m of the transect center line. In order to avoid counting the same bird twice, one species was never registered after if it was heard again in front of the observer unless it was undoubtedly another individual. Observations were made with binoculars (8 × 42) and vocalizations were tape recorded with a built-in microphone cassette recorder. The same direction of travel was followed on both routes, which were sampled twice during the day, once during the mornings and once during the afternoons. Transects comprised the same type of forest (*cerradão* woodland), although I spent 80% of transect counting in open habitats. Routes were sampled every 15 days in September and December 2005 and from January-November 2006. I started all transects 10 min before sunrise and continued until midday, except for a few occasions when I interrupted them at 10:00.

Analyses

In São Paulo, breeding seasons coincide with rainy periods. Therefore, I considered them as the wettest months of the year whereas nonbreeding seasons were the remainder. To evaluate if there are transitional months between wet and dry seasons (Madeira & Fernandes, 1999), I conducted a hierarchical cluster analysis with monthly rainfall values acquired at the municipality of Bauru by the Centro Integrado de Informações Agrometeorológicas (available at www.ciiagro.sp.gov.br) from January 2004-December 2010.

I included a set of two visits (or subsamples) per month in my analyses and the same number of subsamples (n = 10) was considered for both seasons. As subsamples were not independent, which precludes the independence premise to use parametric tests, I used values obtained from the differences between the breeding and nonbreeding monthly counts to analyze data. These values, if positive, indicate how many more species or individuals could be detected during breeding seasons. Data were tested for normality and log-transformed if normality assumptions were violated. I used a two-tailed paired *t*-test to examine differences in the number of species and individuals recorded between seasons.

I decided to exclude non-passerines and analyze only passerine birds once their home range is smaller and their foraging behavior are more appropriate for the questions I elaborated (Cavarzere & Moraes, 2010). Non-passerines' home ranges are much wider and some of the species recorded in our study areas probably do not use them as a restricted habitat year-round. I used a goodness-of-fit *G*-test to compare the distribution of the number of observations of families and species with more than 150 and 50 detections, respectively, between seasons. The null hypothesis was that detections were evenly distributed between the two periods of the year and showed no particular seasonal association. For abundance analysis I considered the number of individuals per 100 h of observations so differences in sampling effort could be factored out.

Herzog *et al.* (2002) suggested using the Chao1 non-parametric estimator for determining at which point the sample effort accumulated was sufficient to detect most species at a particular site. For my data, numbers of subsamples used were considered sufficient if they recorded > 90% of the estimated species richness. Both the Chao1 and the 50-times sample-based randomized species accumulation curves were calculated with EstimateS 8.2 (Colwell, 2009). The alpha level for tests of significance was $\alpha = 0.05$; values in the 'Results' section refer to mean and SD.

RESULTS

Six-year monthly rainfall data described two distinctly rainy months (mean rainfall of 250 mm): January and December. The remaining months could be divided into five equally dry months with a mean rainfall of 35 mm (May, June, July, August and September), and another five months were characterized by intermediate quantities of rain (mean rainfall of 92 mm; Fig. 2). Nevertheless, I concluded that these data represent two, not three seasons. The rainiest and intermediate months correspond to the rainy season, while the five driest months of the year can be considered as the dry season. There is no reason to admit a third season (January and December alone) just because they are the rainiest months and fall in a close related group within the cluster (Fig. 2b). Mean rainfalls throughout the years clearly show January and December as outliers of a seasonal rainfall regime constituted by two distinct seasons (Fig. 2a).

I recorded 10,987 contacts of 168 bird species over a total of 73.5 h at Jardim Botânico and 52.5 h at UNESP. The overall richness was exactly the same during breeding and nonbreeding seasons at JB, but greater during nonbreeding seasons at UNESP. At JB, I recorded 3.5 ± 11.3 more species during the breeding season and 1 ± 60 more individuals during the same season. At UNESP 4.4 ± 8.8 more species were recorded during the breeding period and 6.5 ± 69 indicated that more individuals were detected during the same season (Table 1).

Species accumulation curves almost matched monthly values between seasons at JB, while at UNESP the breeding season showed a tendency towards stabilization, a result not shared with the nonbreeding season (Fig. 3). The estimated number of species (Chao1) for the breeding season at JB and UNESP were 163 and 113, respectively; these values for the non-breeding season were 154 and 103. Only the observed

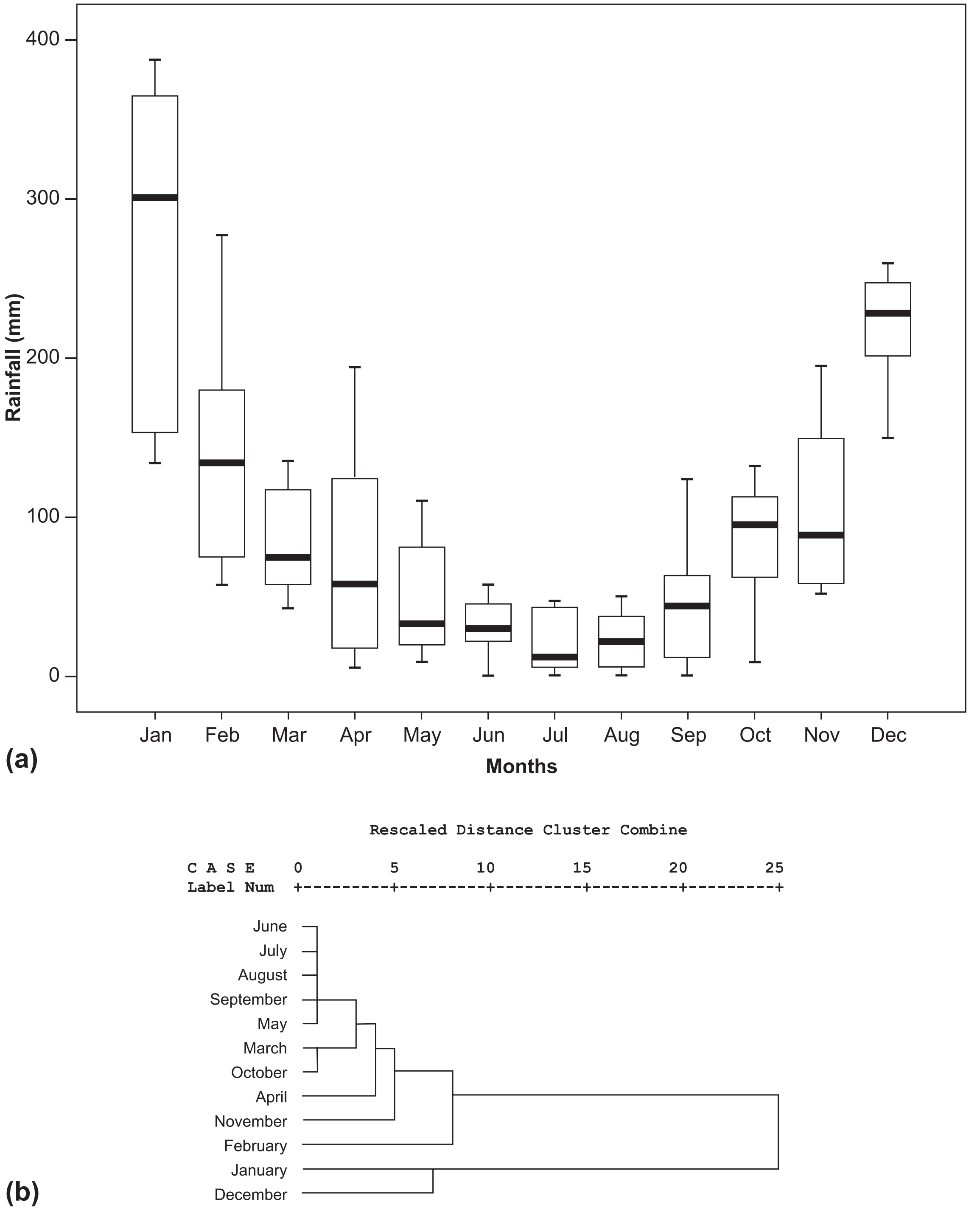

FIGURE 2: Boxplot **(a)** and hierarchical cluster analysis **(b)** of monthly rainfall values collected in Bauru, state of São Paulo, southeastern Brazil, from January 2004-December 2010.

TABLE 1: Number of total and exclusive species and number of individual detections recorded during breeding and nonbreeding seasons in transect counts of birds at the Jardim Botânico and at the UNESP campus in Bauru, state of São Paulo, southeastern Brazil.

	Total	Breeding	%	Exclusive	%	Nonbreeding	%	Exclusive	%
					Jardim Botânico				
Richness	162	144	89	18	11	144	89	18	11
Abundance	6748	3550	53			3198	47		
					UNESP				
Richness	107	95	89	8	7	99	93	12	11
Abundance	4239	2152	51			2087	49		

species richness obtained during the nonbreeding season accounted for 90% of the estimated number of species at both sites, in which case eight subsamples would have been enough to detect most species.

The reproductive season did not consistently obtain more contacts than the nonbreeding season because differences in the numbers of species and individuals varied unpredictably (Fig. 4). Differences in species richness and abundance were not significantly different between seasons at JB ($t_{richness}$ = 0.98, P = 0.354; $t_{abundance}$ = 0.03, P = 0.980) or UNESP ($t_{richness}$ = 1.58, P = 0.148; $t_{abundance}$ = 0.30, P = 0.772). When analyzing families with more than 150 detections, only one (Tyrannidae) tended to be more detectable during breeding counts (Table 2). If summer migrants were removed from this analysis, this family would not show such a pattern (G = 0.28, df = 1, P = 0.599). Of the 29 species with more than 50 detections over the months I surveyed the avifauna, only seven (24%) were more likely to be recorded on a particular season. Among the five species tending to be recorded more often during the breeding season, three were summer migrants (Table 3).

DISCUSSION

My results obtained differences neither in the number of species nor in the number of individuals between seasons. If birds were indeed more detectable during months of increased breeding activity (Blake, 1992; Selmi & Boulinier, 2003; Simon *et al.,* 2002;

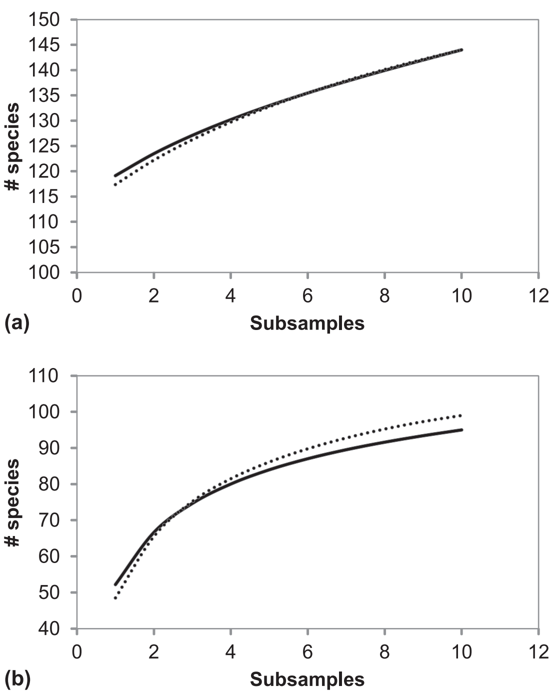

FIGURE 3: Species accumulation curves of the observed number of species according to breeding (solid lines) and nonbreeding seasons (dotted lines) at the Jardim Botânico **(a)** and at the UNESP campus **(b)**, Bauru, state of São Paulo, southeastern Brazil, from September 2005-November 2006.

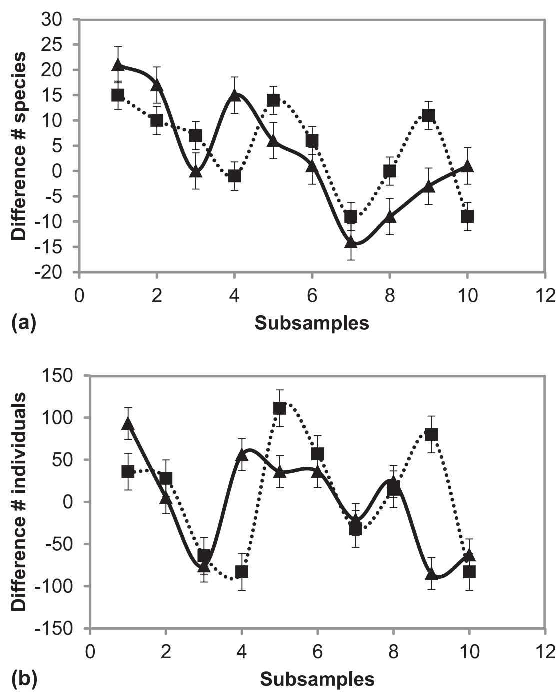

FIGURE 4: Differences in the numbers of species **(a)** and individuals **(b)** recorded during breeding and nonbreeding seasons at the Jardim Botânico (triangles) and at the UNESP campus (squares), Bauru, state of São Paulo, southeastern Brazil, from September 2005-November 2006. Error bars represent SE.

TABLE 2: List of bird families with more than 150 detections during transect counts of birds in Bauru, state of São Paulo, southeastern Brazil. Tyrannidae tended to be recorded more often during breeding season counts, as revealed by goodness-of-fit *G*-tests. Numbers of individuals per 100 h of observations are given. Degrees of freedom = 1 for all.

Families	Breeding season	Nonbreeding season	*G*	*P*
Thamnophilidae	97.6	109.5	0.68	0.408
Tyrannidae	495.2	341.3	28.50	0.000
Thraupidae	253.2	219.0	2.47	0.116
Hirundinidae	92.1	86.5	0.17	0.678
Turdidae	100.0	98.4	0.01	0.910
Emberizidae	161.1	150.0	0.40	0.529
Parulidae	104.8	80.2	3.28	0.070

Blendinger, 2005; Volpato *et al.,* 2009), then they should have been recorded more during the breeding season due to an increase in abundance with the fledging of young birds, or increase in detections due to more conspicuous vocalization during this period (Freifeld *et al.,* 2004). However, overall detections were actually slightly greater during the nonbreeding season at UNESP, and many differences between monthly empirical values of species richness and abundance were negative at both study areas. This indicates that species and individuals are detected unpredictably during these months. Thus, the well-established statement that birds are more conspicuous when they are reproducing may be spurious for these

TABLE 3: List of species with more than 50 detections during transect counts of birds in Bauru, state of São Paulo, southeastern Brazil. Species in bold tended to be recorded more often during breeding season counts, while an asterisk indicates species recorded more often during nonbreeding season counts, as revealed by goodness-of-fit *G*-tests. Mig. = species that leave the study areas during drier months. Numbers of individuals per 100 h of observations are given. Degrees of freedom = 1 for all.

Species	Breeding season	Nonbreeding season	*G*	*P*
Thamnophilus doliatus	28.6	36.5	0.97	0.325
Thamnophilus pelzelni	30.2	21.4	1.48	0.223
Herpsilochmus atricapillus	21.4	23.0	0.06	0.812
Furnarius rufus	24.6	31.7	0.91	0.341
Elaenia flavogaster	45.2	54.0	0.77	0.380
*Camptostoma obsoletum**	16.7	30.2	3.94	0.047
Myiozetetes similis	30.2	15.1	5.12	0.024
Pitangus sulphuratus	44.4	39.7	0.27	0.604
Tyrannus melancholicus^{mig}	75.4	11.9	51.48	0.000
Tyrannus savana^{mig}	42.9	7.9	26.39	0.000
Antilophia galeata	38.9	43.7	0.27	0.600
Vireo olivaceus^{mig}	54.0	11.1	30.73	0.000
Progne chalybea	71.4	42.9	7.22	0.007
Pygochelidon cyanoleuca	127.8	115.9	0.58	0.446
Stelgidopteryx ruficollis	49.2	44.4	0.24	0.623
Troglodytes musculus	34.9	37.3	0.08	0.779
Turdus leucomelas	69.8	64.3	0.23	0.631
Turdus amaurochalinus	21.4	19.0	0.14	0.708
Mimus saturninus	52.4	65.9	1.54	0.214
Coereba flaveola	31.7	36.5	0.33	0.564
Thraupis sayaca	49.2	35.7	2.15	0.142
Tangara cayana	25.4	27.0	0.05	0.826
Volatinia jacarina	85.7	71.4	1.30	0.254
*Sporophila caerulescens**	12.7	53.2	26.74	0.000
Basileuterus flaveolus	77.8	55.6	3.72	0.054
Pseudoleistes guirahuro	19.0	21.4	0.14	0.708
Molothrus bonariensis	27.8	33.3	0.51	0.477
Euphonia chlorotica	28.6	34.9	0.64	0.425
Passer domesticus	72.2	72.2	0.00	1.000

study areas. In addition, the observed species richness accounted for > 90% of the estimated number of species during nonbreeding seasons only, indicating that most species were more rapidly detected during colder and drier months.

Excluding summer migrants, which are obviously recorded more during reproductive seasons as they leave the areas during drier (cooler) months, none of the families were detected more often in a particular season and less than one third of the species with more than 50 detections were likely to be recorded more often during one season. Even the addition of such migrants did not raise the number of species or individuals recorded during breeding seasons (*G*-test, $P > 0.05$). Therefore, conducting surveys during this typically rainy period will not compensate for sampling birds because the same results (regarding species richness and abundance, not community composition) can be obtained during drier months. This is an important finding because one of the major issues concerning fieldwork in Neotropical regions is conducting it during inclement weather, a limiting factor that makes bird censuses inappropriate (Herzog *et al.,* 2002).

Only two species had an opposite pattern of detection, being more abundant during nonbreeding season months: *Sporophila caerulescens* and *Camptostoma obsoletum.* The decrease in individuals may account for migratory movements of *S. caerulescens* during drier months, a well-known fact for this seedeater species. The tyrannulet may have been overlooked during colder months, but the species has been suggested to have migratory movements in South America as well (Chesser, 1994).

The difference in detections between reproductive seasons may be a result of northern latitudes. Investigators from temperate habitats have focused bird counts on reproductive seasons because the rate of calling and singing of most species exhibit short and only partially overlapped periods when detectability is relatively stable (Buskirk & McDonald, 1995). Neotropical species probably behave differently (*e.g.,* fewer migratory species, constant vocal behavior throughout the year) and should be as detectable during breeding as nonbreeding seasons, as previously found for tropical and Neotropical region birds (Calladine *et al.,* 1999; Freifeld *et al.,* 2004; Brandolin *et al.,* 2007; Volpato *et al.,* 2009).

Other approaches regarding the efficiency of bird surveys demonstrated that studies must adapt their field method according to the scope of their investigation. For example, some species may be detected more often during afternoon instead of morning counts, compelling researchers to understand the biology of the taxon under consideration before conducting field experiments (Cavarzere & Moraes, 2010). It is imperative that more investigations on the use of survey methods be tackled immediately, for many concepts and protocols that are currently considered as appropriate may no longer be adequate for their intended purposes in Neotropical regions. Questions on method efficiency can be elaborated even during Rapid Assessment Programs. While generating important information on improving field methods and on the ranges and biology of species, these data can also be availed for conservation purposes.

RESUMO

Estudos em regiões temperadas demonstraram que as aves são mais ativas durante períodos reprodutivos, os quais são consequentemente considerados mais eficientes para o censo de aves. No Estado de São Paulo, sudeste do Brasil, os meses mais chuvosos são geralmente associados aos picos de reprodução da avifauna. Para testar a hipótese de que as aves são igualmente detectáveis ao longo do ano, foi realizado o censo das aves de uma área de cerrado predominantemente aberto no interior de São Paulo utilizando-se a metodologia de transecção linear entre os anos de 2005 e 2006. Não houve diferença significativa do número de espécies ou do número de contatos registrado entre períodos reprodutivo (chuvoso) e não reprodutivo (seco); 24% das espécies com mais de 50 contatos tendeu a ser significativamente mais comum em um dos dois períodos. Diferente de regiões temperadas, onde o comportamento vocal das aves influencia sua detectabilidade durante e após estações reprodutivas, resultados aqui encontrados sugerem que aves de cerrado podem ser igualmente detectáveis ao longo do ano.

Palavras-Chave: Abundância sazonal; Clima sazonal; Estação reprodutiva; Período de amostragem; Região neotropical; Riqueza sazonal.

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