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Diurnal variation in transect counts of birds in a cerrado landscape in the state of São Paulo, Brazil

Vagner Cavarzere[1] and Gabriel Parmezani Moraes[2]

[1] Corresponding author. Departamento de Zoologia, Universidade de São Paulo. Rua do Matão, Travessa 14, nº 101, 05508-900, São Paulo, SP, Brasil. E-mail: cavarzere@usp.br.

[2] Departamento de Ciências Biológicas, Universidade Estadual Paulista. Rua Engenheiro Luiz Edmundo Carrijo Coube, 14-01, 17033-360, Bauru, SP, Brasil. E-mail: g_moraes@hotmail.com.

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RESUMO: Variação diurna de aves amostradas por transecções em áreas de cerrado de São Paulo, Brasil. Por incluírem o período de maior atividade das aves, as manhãs são consideradas melhores que as tardes para amostragem deste grupo. Embora muitos pesquisadores tenham realizado estudos sobre variações temporais na detecção de aves com Pontos de Escuta em regiões temperadas, transecções lineares e habitats neotropicais foram pouco explorados na tentativa de responder as mesmas questões. A metodologia de transecções foi utilizada para testar a hipótese de que as aves são registradas igualmente durante dois períodos do dia em um ambiente de cerrado predominantemente aberto no sudeste do Brasil. Embora nem sempre de maneira significativa, o número de espécies e de indivíduos foi consistentemente maior durante as manhãs, corroborando a idéia de que as aves podem ser mais detectáveis durante esse período do dia. No entanto, algumas famílias, assim como uma pequena porcentagem de espécies, demonstraram preferências de detecção durante um dos dois períodos analisados. Os resultados sugerem que, no ambiente estudado, as manhãs são mais adequadas para a amostragem de um número maior de espécies e de indivíduos, porém táxons específicos variam seus padrões de detecção e devem ser avaliados anteriormente às amostragens.

PALAVRAS-CHAVE: Abundância, detecção visual, padrões de detecção, neotrópico, período do dia, riqueza.

ABSTRACT: The general statement that birds are recorded more often on morning than on afternoon counts is quite common and widespread among ornithologists. Although many investigators have reported temporal variations in bird detections using Point Counts in temperate regions, few researches regarding the same objectives have been conducted in Neotropical habitats or used transect counts as field method. We used transect counts to test the hypothesis that birds are evenly recorded between times of day in a predominantly open *Cerrado* landscape in southeastern Brazil. Although not always significantly, the number of species and individuals were consistently greater during the morning counts, which corroborates the fact that birds can be more detectable during this time of day. However, a few families as well as a small percentage of species were more likely to be recorded during either one of the two periods we analyzed. Our results suggest that morning counts should detect higher number of both species and individuals in our study area, but specific taxa show distinct patterns of detection which should be acknowledged prior to sampling.

KEY-WORDS: Abundance, Neotropical region, patterns of detection, richness, time of day, visual detection.

Point Counts were developed by Blondel *et al.* (1970) to estimate bird community densities and were specifically designed for temperate habitats. Many authors have investigated hourly variation of birds using this method (Skirvin 1981, Blake 1992, Betini 2001) and most of these approaches have set a globally accepted trend, in which census are best employed when birds are more active and therefore more detectable during the first hours of the day. Some deviations from this pattern can occur (Dawson 1981, Verner and Ritter 1986) and much work is still needed to improve bird counting techniques (Blake 1992).

Few studies on diurnal variation in detections of Neotropical birds have been carried out to date (Blake 1992, Lynch 1995, Betini 2001) and investigations using transect counts are even rarer or were either conducted in the northern hemisphere (Järvinen *et al.* 1977, Shields 1977, Blake *et al.* 1991) or only recently in the Neotropics (Antunes 2008). While many investigations have focused forested habitats (Blake 1992), open formations have never been the aim of studies on temporal variations of tropical birds.

On situations in which surveys must be sampled in open areas, such as *Cerrado* formations (Eiten 1972), transects are more indicated than Point Counts since they are based on visual rather than aural detections (Bibby *et al.* 1993, Develey 2003). As methods are recklessly used without previous tests concerning its efficiency or habitat type (Betini 2001), it is important one investigates factors that influence bird count censuses (Blake 1992).

Here we present our results on diurnal variation of birds using transect counts during six months in a predominantly open *Cerrado* landscape in the state of São Paulo, Brazil. We specifically wanted to: (A) test the hypothesis that birds, measured as number of species and individuals, are evenly recorded during two distinct periods of the day (mornings and afternoons) and (B) examine whether particular taxa exhibit specific preference to be recorded more often during one of these periods.

METHODS

Study area

We conducted this research at the Jardim Botânico Municipal de Bauru and at the *campus* of the Universidade Estadual Paulista (UNESP), located in the city of Bauru (22°20'S 49°00'W), near the center of the state of São Paulo, Brazil. The study areas belong to the *Cerrado* Biome and include mature *cerradão* (closed-canopy dry forest), seasonal semideciduous forest and alluvial forest (Cavassan *et al.* 1984).

The UNESP *campus* has anthropogenic environments such as orchards and *Brachiaria* sp. grassy fields. There are also lakes and regenerating second growth, all reachable by roads or routes. Dry periods occur from April to September and rainy season lasts from October to March (Cavassan *et al.* 1984).

Bird count

We established two transect lines (1.5 km ± 0.3; mean ± SD) 1.5 km apart running across all environments in the study areas but predominantly ranging over open habitats. Observers (VC and GPM) 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 observers unless it was undoubtedly another individual. Observations were made with binoculars (8 × 42) and vocalizations were tape recorded with a Panasonic RQ-L31. 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 formation (*cerradão*) although we spent 80% of transect counting in open habitats.

We counted birds every 15 days from September-December 2005 and complemented our sampling effort visiting the localities on a monthly basis during January and February 2006. We started all transects from 5 to 10 min before sun rise and continued until mid-day, except for a few occasions when we interrupted them at 10:00.

Analyses

We conducted 20 visits (subsamples) to the areas during the months we counted the birds and we analyzed the same number of subsamples (n = 10) for mornings and afternoons. As subsamples were not independent, which precludes the independence premise to use parametric tests, we used values obtained from the differences between mornings and afternoons to analyze data. These values indicate how many more species or individuals could be detected during the morning counts. After normality tests, we used a two-tailed paired t-test to examine the differences in numbers of species and individuals between times of day. We examined variations for each route separately and pooling data from both spatial replicates.

We decided to exclude non-passerines and analyze only the passerine birds once their home range is smaller and their foraging behavior is more appropriate for the questions we elaborated. 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.

Finally, we 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 times of day. The null hypothesis was that detections were evenly distributed between periods of day and showed no particular temporal association.

For abundance analysis we considered abundance as the number of individuals counted per 100 h so that differences in sampling effort could be factored out. The alpha level for tests of significance was $\alpha = 0.05$. The values in the 'Results' section refer to mean and SD.

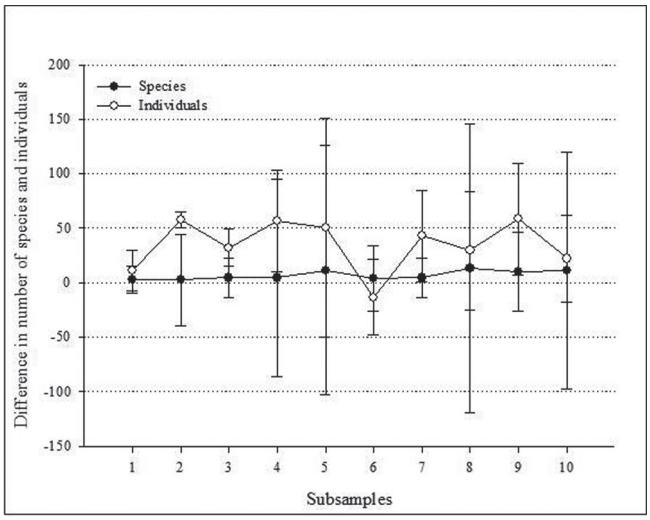

FIGURE 1: Mean differences in number of species and individuals recorded on two transect counts in Bauru, São Paulo, Brazil. Error bars represent ± SE.

TABLE 1: Species richness and number of individuals recorded on morning and afternoon counts for two separate transect routes at the Jardim Botânico and at the UNESP *campus* in Bauru, state of São Paulo, Brazil.

	Total	Mornings	%	Exclusive	%	Afternoons	%	Exclusive	%
					Jardim Botânico				
Richness	140	130	93	17	12	123	88	10	7
Abundance	4080	2298	56			1782	44		
					UNESP				
Richness	95	85	89	10	11	89	94	6	6
Abundance	4965	2573	52			2392	48		

TABLE 2: Results of differences in species richness and number of individuals between morning and afternoon counts in Bauru, state of São Paulo, Brazil, revealed by two-tailed paired t-tests. Degrees of freedom = 9 for all.

	Jardim Botânico		UNESP		Pooled data	
	t	P	t	P	t	P
Richness	4.18	0.002	2.14	0.061	5.30	0.000
Abundance	2.75	0.023	1.26	0.240	2.08	0.285

TABLE 3: List of families with more than 150 detections in Bauru, state of São Paulo, Brazil. Bolded ones tended to be recorded more often during the morning counts, while an asterisk indicates families recorded more often on afternoon 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	Time of day		G	P
	Morning	Afternoon		
Thamnophilidae	235.2	59.3	112.48	0.000
Tyrannidae	757.4	585.2	22.15	0.000
Vireonidae	196.3	114.8	21.59	0.000
Hirundinidae*	277.8	431.5	33.57	0.000
Turdidae	200.0	161.1	4.20	0.041
Emberizidae	227.8	224.1	0.03	0.862

TABLE 4: List of species with more than 50 detections in Bauru, state of São Paulo, Brazil. Bolded ones tended to be recorded more often during the morning counts, while an asterisk indicates species recorded more often on afternoon 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.

Species	Time of day		G	P
	Morning	Afternoon		
Thamnophilus pelzelni	90.7	18.5	65.38	0.000
Furnarius rufus	59.3	42.6	0.00	0.098
Elaenia flavogaster	55.6	40.7	0.03	0.130
Pitangus sulphuratus	83.3	48.1	2.89	0.002
Myiodynastes maculatus	63.0	31.5	5.74	0.001
Megarynchus pitangua	51.9	44.4	1.62	0.450
Empidonomus varius	53.7	53.7	6.17	1.000
Tyrannus melancholicus	100.0	88.9	4.57	0.419
Tyrannus savana	77.8	66.7	2.43	0.355
Antilophia galeata	92.6	61.1	0.48	0.011
Vireo olivaceus	125.9	77.8	2.12	0.001
*Pygochelidon cyanoleuca**	231.5	359.3	176.18	0.000
Turdus leucomelas	148.1	103.7	0.05	0.005
Mimus saturninus	74.1	66.7	3.81	0.532
Thraupis sayaca	55.6	37.0	0.22	0.053
Volatinia jacarina	137.0	109.3	1.50	0.076
Basileuterus flaveolus	155.6	68.5	18.75	0.000
Molothrus bonariensis	68.5	75.9	14.11	0.538
Euphonia chlorotica	70.4	51.9	0.06	0.093
Passer domesticus	111.1	105.6	8.93	0.706

RESULTS

We recorded a total of 144 species in 9045 contacts during 31.5 h at the Jardim Botânico and during 22.5 h at the UNESP *campus*. The overall species richness and abundance were greater on morning counts except for the species richness at the UNESP *campus;* the percentage of species exclusively recorded during the periods of the day was quite similar for both sites (Tables 1 and 2).

Considering both spatial replicates, morning counts consistently recorded more species and individuals (except for individuals recorded on subsample 6) than afternoon counts (Figure 1). At the Jardim Botânico, we recorded 10.45 ± 8.10 more species during the morning than during the afternoon counts and 93.82 ± 59.42 more individuals in the same situation. At the UNESP *campus* these values were 2.27 ± 4.28 and 32.55 ± 45.53, respectively, whereas pooled data revealed 6.80 ± 4.06 more species and 34.75 ± 23.46 more individuals for the morning time.

Differences in species richness and abundance were significantly greater on mornings at the Jardim Botânico, although these variables did not differ significantly at the UNESP *campus;* when pooling data, only richness was significantly different between times of day (Table 2). Additionally, some species may have individually accounted for more records during a specific period of the day, so we ran our analyses once more without them. As a result, the number of individual detections increased significantly on morning counts the UNESP *campus* ($t_{abundance}$ = 2.79; df = 9; P = 0.021).

When analyzing the families with more than 150 detections, only one (Emberizidae) did not tend to be more

detectable during one specific period of the day while the Hirundinidae were registered more often during the afternoon counts (Table 3). Of the 20 species with more than 50 detections, seven were more likely to be recorded during the morning counts and the Blue-and-white Swallow *Pygochelidon cyanoleuca* was the only species recorded more often on afternoons (Table 4).

DISCUSSION

Our results partly supported the general statement that birds are more detectable during the mornings (Shields 1977, Skirvin 1981, Pizo *et al.* 1997) because a significant higher number of species was recorded at the Jardim Botânico and when pooling data. However it may be not suggested that mornings are always more fruitful to conduct transect counts in open Neotropical habitats. These reasons are two-fold: (1) the UNESP site and the difference in number of individuals detected when pooling data strongly deviated from these findings and (2) most SE intervals in Figure 1 crossed the zero line (non-significant differences). This indicates that, although morning counts do consistently record more species and individuals, such differences may be not as evident as previously considered.

If one looks at the overall number of species recorded on morning and afternoon counts in Table 1 he will probably tend to consider the first period more appropriate to conduct bird surveys. But a further glimpse at Figure 1 clarifies that only few more species could be recorded during the morning than during the afternoon counts. Thus, mornings may be used to rapidly assess the great majority of bird species of an area while afternoons may be used for the same purpose if somewhat greater effort is spent. Unfortunately, we did not tease apart visual from aural detections, which could detect distinct patterns for our results.

Järvinen *et al.* (1977) investigated diurnal variation in detections of birds using transect counts in Finland and reported significant greater number of species and detections for mornings. Blake (1992) did find richness peaks on late afternoons using Point Counts in Costa Rica, but his results still yielded higher numbers of species detected during the beginning of the days. Although without controlling for differences in sampling effort between times of day, Antunes (2008) concluded that in a São Paulo semideciduous forest birds are more detectable during the morning counts using transects. Comparing these three investigations with our own findings, this UNESP's route seemed to represent an outlier and it may have been biased by counting birds in partially anthropogenic habitats.

Also our results probably reflected the variability observed for few species that individually accounted for more records during a specific period of day such as the Planalto Slaty-Antshrike *Thamnophilus pelzelni,* the Helmeted Manakin *Antilophia galeata* and the Flavescent Warbler *Basileuterus flaveolus,* three of the seven species recorded more often during the morning counts (Table 4). This is further supported by the fact that if such species were removed from our analysis, the number of individual detections would increase significantly on morning counts at the UNESP *campus.*

Foraging behavior and biology may drive some diurnal patterns of detection in our study areas. The Hirundinidae consume insects while soaring. This behavior match with the tendency to be detected more often during the afternoon counts. Also, the dependence on forested habitats seemed to play an important role here. Most of the species recorded more often during the morning counts were forest-dependent or at least semi-dependent on these habitats (Pale-breasted Thrush *Turdus leucomelas;* Silva 1995). The only exception was the Great Kiskadee *Pitangus sulphuratus,* typical of open environments but still recorded more often during the morning counts. These patterns may indicate that forests should be sampled during the mornings as birds tend to be more detectable during this period. Aerial-foraging birds, however, may be sampled during the afternoons for birds should be more detectable later in the day.

Therefore, sampling procedures must be designed according to the scope of the investigation (Blake 1992). At community levels, mornings may be censused alone because afternoon counts should record lower numbers of species and individuals. However, families or species-specific preferences or behavior must be taken into account before conducting field surveys. Forest-independent tyrannids, swallows and finches, for example, are recorded more on afternoons.

Our results apply to one *Cerrado* site in São Paulo and morning counts, although not as evident as previously considered, did consistently record more species and individuals than afternoon counts. Some species were more likely to be recorded during either one of these times of day. Disagreements found within diurnal variation in species richness and abundance using the same method deserves further investigation and much more effort must be spent to improve the designing of counting techniques in Neotropical habitats.

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