Diurnal and seasonal variability in bird counts in a forest fragment in southeastern Brazil

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ABSTRACT. Diurnal variation in detection can influence bird census results. I measured variation in daily and seasonal detections of birds in a forest fragment at Barreiro Rico ranch, Anhembi, state of São Paulo. Birds were recorded on transects of unlimited distance, sampled one day per month, dawn to dusk, between December 2000 and March 2001 (rainy season) and between May and August 2001 (dry season). Significant daily variation in detection occurred during the rainy season, with most detections between dawn and 9 h. In the dry season detections declined for total numbers of individuals and species and most detections occurred during late morning and mid afternoon. Detection patterns might reflect seasonal variation in bird behavior rather than seasonal variation in species composition.
KEY WORDS. Atlantic Forest; census; detection; seasonal variation; transects.

RESUMO. **Variação no registro de aves ao longo do dia num fragmento florestal do sudeste do Brasil.** A variação nos padrões de detecção é um dos fatores que interfere nos resultados de levantamentos de aves. Essa variação foi avaliada ao longo do dia e sazonalmente para a comunidade de aves de um fragmento florestal localizado na fazenda Barreiro Rico, Anhembi, São Paulo. O método utilizado foi o de trajetos de distância ilimitada, efetuados em um período diurno inteiro por mês, entre dezembro de 2000 e março de 2001 (estação chuvosa) e entre maio e agosto de 2001 (estação seca). Houve variação significativa na detecção ao longo do dia para a estação chuvosa, com o maior número de contatos obtidos do amanhecer às 9 h. Durante a estação seca foram contatados menos indivíduos, com maiores proporções de registros no final da manhã e no meio da tarde. Estas diferenças devem estar mais relacionadas às variações sazonais no comportamento das aves, do que às alterações na composição da comunidade entre estações.
PALAVRAS-CHAVE. Censos; detecção; Mata Atlântica; trajetos; variação sazonal.

Bird surveys permit analysis of the avifauna in a given area, as well as to define priority areas for biodiversity conservation and to evaluate responses to threats or conservation strategies. Diurnal variability in activity patterns, reflected in detection patterns, can influence results of these surveys (Dawson 1981, Karr 1981, Verner 1985, Parker 1991). Most studies find that detections are greater during early morning (Järvinen *et al*. 1977, Skirvin 1981, Blake 1992, Lynch 1995, Bibby *et al*. 1998). However, within a given community, species vary with respect to their daily and seasonal activity patterns, resulting in different general patterns shown by some studies (Dawson 1981, Robbins 1981, Verner & Ritter 1986, Blake *et al*. 1991, Pizo *et al*. 1997).

The objectives here were to: 1) determine whether hourly variation occurs in the number of species counted and the total number of detections, in a bird community in a forest fragment in southeastern Brazil; 2) compare hourly detection patterns between wet and dry seasons; and 3) examine how these patterns vary among species or between trophic groups or groups that foraging in the same strata.

MATERIAL AND METHODS

This study was carried out in a forest fragment of 1451 ha (22º45'S, 48º09'W), at the Barreiro Rico ranch, Anhembi municipality, in the state of São Paulo. The forest fragment is seasonally semideciduous (Assumpção *et al*. 1982, Cesar & Leitão-Filho 1990). Altitude varies from 450-586 m and climate is Köppen type Cwa, with average annual rainfall of 1282.4 mm and average annual temperature 21.5ºC (Magalhães 1999).

Birds were sampled on distance-unlimited transects (Willis 1979, Bibby *et al*. 1998) throughout the day one day each month, from December 2000 to March 2001 (wet season) and May-August 2001 (dry season). Local total rainfall during this sampling period (from the ranch meteorological station) was 633.9 mm (wet season) and 207.4 mm (dry season). Samples began at dawn (wet season ~5 h, dry season ~6 h) and continued to dusk (~19h and ~18 h respectively). Total sampling effort was 56 hours during the wet season and 48 hours during the dry season.

Samples were carried out on two permanent trails (1.5 and 3.5 km) and six trails maintained during the study period that ranged from 500-1000 m, perpendicular to the two permanent trails, all of which were > 50 m from the edge. The sampled area, in the central eastern area of the fragment, is forest in mid or advanced stages of succession, with few openings and clumps of bamboo.

Trails were walked slowly and all birds seen or heard were counted. Binoculars (8 x 40) and tape recorder (Nagra E) with directional Sennheiser MKH 816 T microphone were used to aid identification.

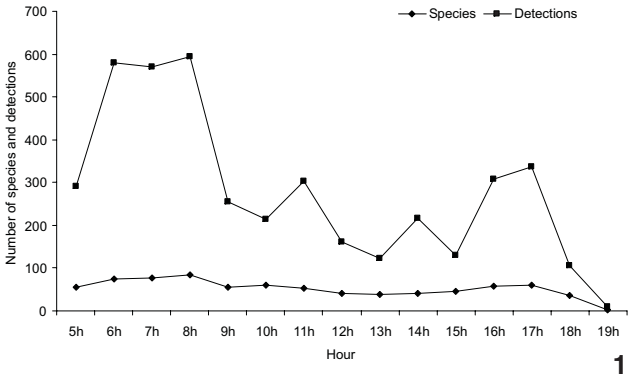
Nomenclature follows the Brazilian Comittee for Ornithological Registry (Cbro 2007). Birds were grouped into five guilds as follows: carnivore, frugivore and granivore, insectivore, nectarivore and omnivore and into two foraging strata: canopy and understory. These definitions follow Willis (1979) and personal observations.

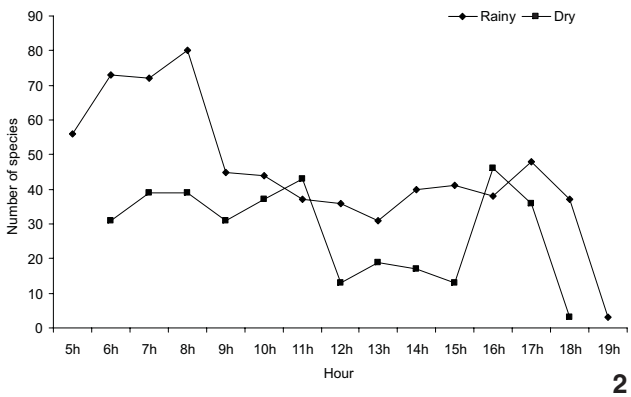
Hourly variation in number of species detected and total number of detections were examined by correlations with hour of the day, by Spearman rank correlations (rs, Fowler & Cohen 1995). This non-parametric test is used to determine the level of association between two ranked variables. When testing correlations with individual species, the species used were limited to those with sample size > 50 detections by season. Significance is considered when $p < 0.05$.

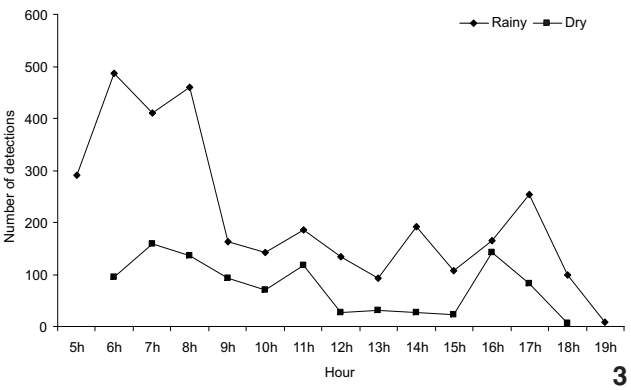
RESULTS

A total of 107 species were detected in 4769 individuals. Of these, 104 species and 3184 detections were during the wet season, and 82 species (955 individuals) during the dry season (Tab. I). Hourly variation in detection was found for number of species ($rs = -0.58$, $n = 15$, $p < 0.05$) and number of individuals ($rs = -0.61$, $n = 15$, $p < 0.05$) (Fig. 1). In both, the pattern was similar and comprised an increase in detections between dawn and 08:00-09:00, after which detections declined sharply. A second peak, smaller than the first, occurred between 12-13 sample hours (16:00-18:00), with another rapid decrease to dusk. However, behavior of the two variables differed after the first decline. While the number of species declined gradually until 14:00 followed by a gradual increase until 18:00, the total number of detections oscillated with sporadic increases and decreases.

During the wet season the pattern was similar. The number of species ($rs = -0.61$, $n = 15$, $p < 0.05$) and the number of detections ($rs = -0.72$, $n = 15$, $p < 0.01$) both were correlated with hour of the day (Fig. 2). The number of species encountered reached a maximum at 08:00-09:00 (four hours after dawn), after which declined sharply until 13:00-14:00 (nine hours after dawn), followed by an increase until 17:00-18:00 (13 hours after dawn), when it declined again until dusk. The maximum number of detections per hour was greatest at 06:00-07:00 (second hour after dawn), followed by a decline after 08:00-09:00 after which the number oscillated during 11:00-16:00, with a second peak just before dusk (17:00-18:00, Fig. 3).







Figures 1-3. (1) Number of species and total number of detections by hour of the day; (2-3) Number of species (2) and total number of detections (3) by hour and season.

During the dry season, patterns were not evident. Neither number of species ($rs = -0.17$, $n = 13$, $p > 0.05$) nor number of detections ($rs = -0.44$, $n = 13$, $p > 0.05$) were related to hour of the day (Fig. 2). For number of species, the pattern was different from that of the rainy season in that two peaks in detections occurred, one at 11:00-12:00 (six hours after dawn) followed by a decline (12:00-16:00) and then again at 16:00-17:00 (11 hours after dawn) followed by a decline until dusk. For the total number of detections, the two seasons were similar. Again,

two peaks in detections occurred, the first at 07:00-08:00 (two hours after dawn) and the second at 16:00-17:00 (Fig. 3). Mid-day detections declined after 12:00 stabilizing around 16:00.

Eight species were migratory (349 detections, 9% of the wet season total) and absent during the dry period (Tab. I). Excluding these from the analysis, patterns did not change during the wet season: number of species (r_s = -0.58, n = 15, $p < 0.05$) and total detections (r_s = -0.60, n = 15, $p < 0.05$). Only one migratory species, *Laniisoma elegans* (Thunberg, 1823) Tityridae, was detected during the dry season.

Between 05:00-09:00, 98 species (91%) were detected. Of the nine detected outside this interval, seven were exclusively crepuscular, from 17:00-19:00: *Odontophorus capueira* (Spix, 1825) Odontophoridae; *Megascops atricapilla* (Temminck, 1822) Strigidae; *Trogon rufus* Gmelin, 1788 Trogonidae; *Xiphocolaptes albicollis* (Vieillot, 1818) Dendrocolaptidae; *Dendrocolaptes platyrostris* Spix, 1825 Dendrocolaptidae; *Xenops minutus* (Sparrman, 1788) Furnariidae and *Turdus leucomelas* Vieillot, 1818 Turdidae. In addition to these crepuscular species, there were basically three species detection patterns throughout the day (Tab. I, Figs 4-6).

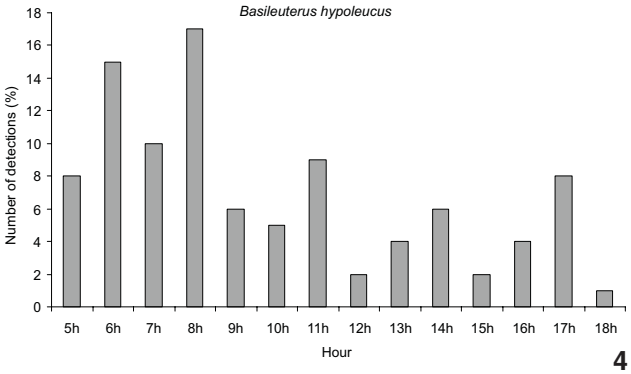
The first includes the majority of species (n = 60 species), was the peak between dawn and 09:00. The second (n = 30) had two peaks, the first at dawn and the second at dusk. The third group (n = 10) was more or less randomly detected throughout the day. No seasonal pattern was observed for these species.

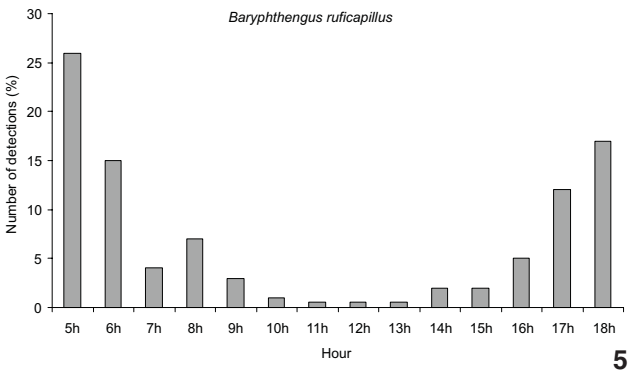
For species with n > 50 detections, only four followed the pattern previously described for the community: *Lathrotriccus euleri* (Cabanis, 1868) Tyrannidae (r_s = -0.61, n = 15, $p < 0.05$), *Cyclarhis gujanensis* (Gmelin, 1789) Vireonidae (r_s = -0.57, n = 15, $p < 0.05$), *Vireo olivaceus* (Linnaeus, 1766) Vireonidae (r_s = -0.56, n = 15, $p < 0.05$) and *Basileuterus hypoleucus* Bonaparte, 1830 Parulidae (r_s = -0.56, n = 15, $p < 0.05$). The latter two species were among the most common, with 241 and 201 detections (6 and 5% of the total), yet the pattern is not due to them, since removing them from the analysis does not alter the pattern for detections (r_s = -0.62, n = 15, $p < 0.05$).

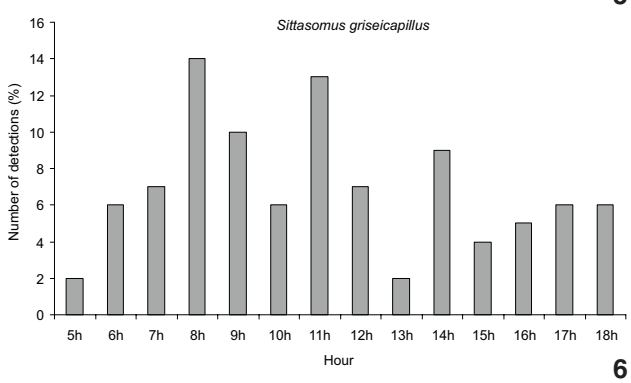
Of the trophic guilds and foraging strata, carnivores and nectarivores were not analyzed due to small sample size. Of the remainder, insectivores alone were not correlated, either in species or detections, with time of day during the rainy season (Tab. II). During the dry season, only the total detections of understory birds showed patterns (Tab. II, Figs 7 and 8).

Insectivores, during the wet season, were detected more often within the hour after dawn, while omnivores were more often detected 15:00-16:00, and frugivores three hours after dawn (Fig. 7). During the dry season, the number of detections in all groups was greater in the morning than afternoon. For frugivores, species were most detected during the second hour after dawn and an hour before dusk. More insectivore species were detected 08:00-09:00 while more frugivore species were detected 07:00-08:00 (Fig. 7).

With respect to stratum, the number of species detected in the canopy declined towards the end of the afternoon a bit before the decline in the understory, while total detections in the canopy was around three hours after dawn (Fig. 8). In the dry season, the number of species detected was greatest 11:00-12:00 in the understory, while the number of species and total number of detections was greatest 16:00-17:00 (Fig. 8).







Figures 4-6. Detection patterns throughout the day, for three species: (4) most detections between dawn and 09:00; (5) peaks of detections during the morning and dusk;(6) random distribution.

DISCUSSION

The decline throughout the day in number of species is similar to that in other studies (Skirvin 1981, Blake *et al*. 1991, Blake 1992) and supports the suggestion that these patterns

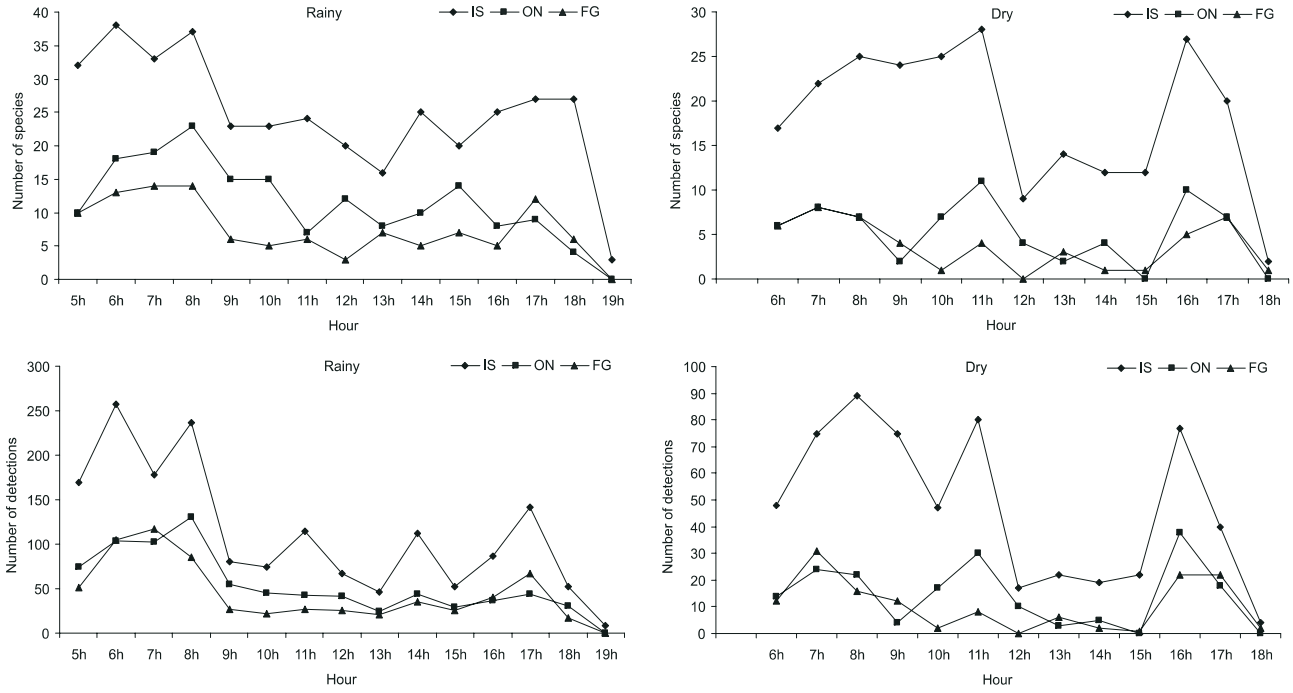


Figure 7. Daily variation in the number of species and the total number of detections by guild during the wet and dry seasons. (FG) Frugivores, (IS) insectivores, (ON) omnivores.

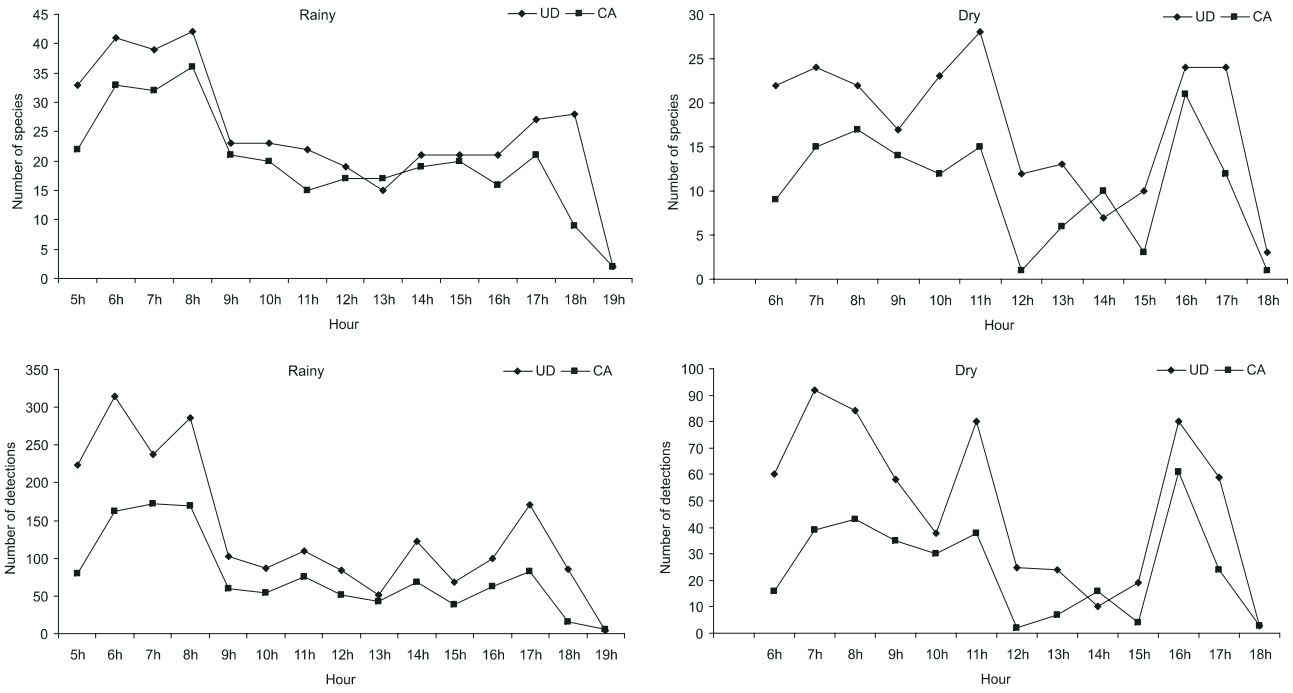


Figure 8. Daily variation in the number of species and total detections, by foraging strata, compared by season. (CA) Canopy, (UD) understory.

Table I. Birds recorded in the 1450 ha forest fragment at Barreiro Rico ranch, Anhembi, São Paulo, with totals by season, trophic guild, foraging stratum, and detection pattern during the day (PD). (CA) Canopy; (UD) understory; (M) migratory species; detection patterns: (I) most detections between dawn and 09:00; (II) two peaks, one at dawn, the other dusk; (III) random; (IV) exclusively crepuscular.

Species	Season		Habit	Stratum	PD
	Wet	Dry			
Tinamiformes					
Tinamidae					
Crypturellus obsoletus (Temminck, 1815)	5	0	Frugivore	UD	I
Crypturellus tataupa (Temminck, 1815)	19	6	Frugivore	UD	I
Galliformes					
Cracidae					
Penelope superciliaris Temminck, 1815	4	0	Frugivore	CA	I
Odontophoridae					
Odontophorus capueira (Spix, 1825)	10	6	Frugivore	UD	IV
Falconiformes					
Falconidae					
Herpetotheres cachinnans (Linnaeus, 1758)	4	4	CarnIvore	CA	I
Columbiformes					
Columbidae					
Patagioenas picazuro (Temminck, 1813)	65	22	Frugivore	CA	I
Patagioenas cayennensis (Bonnaterre, 1792)	18	5	Frugivore	CA	I
Leptotila verreauxi Bonaparte, 1855	287	40	Frugivore	UD	I
Geotrygon violacea (Temminck, 1809)	12	0	Frugivore	UD	I
Psittaciformes					
Psittacidae					
Primolius maracana (Vieillot, 1816)	18	8	Frugivore	CA	I
Aratinga leucophthalma (Statius Muller, 1776)	36	0	Frugivore	CA	I
Pyrrhura frontalis (Vieillot, 1817)	7	2	Frugivore	CA	II
Pionus maximiliani (Kuhl, 1820)	54	8	Frugivore	CA	I
Amazona aestiva (Linnaeus, 1758)	24	12	Frugivore	CA	II
Cuculiformes					
Cuculidae					
Piaya cayana (Linnaeus, 1766)	31	18	Insectivore	CA	III
Strigiformes					
Strigidae					
Megascops atricapilla (Temminck, 1822)	3	0	Carnivore	CA	IV
Glaucidium brasilianum (Gmelin, 1788)	4	5	Carnivore	CA	II
Caprimulgiformes					
Caprimulgidae					
Lurocalis semitorquatus (Gmelin, 1789)	7	0	Insectivore	CA (M)	II
Nyctiphrynus ocellatus (Tschudi, 1844)	7	1	Insectivore	UD	II
Apodiformes					
Trochilidae					
Phaethornis pretrei (Lesson & Delattre, 1839)	5	3	Nectarivore	UD	I
Thalurania glaucopis (Gmelin, 1788)	4	1	Nectarivore	UD	I
Hylocharis chrysura (Shaw, 1812)	3	0	Nectarivore	UD	I
Amazilia versicolor (Vieillot, 1818)	7	1	Nectarivore	UD	I

Continue

Table I. Continued.

Species	Season		Habit	Stratum	PD
	Wet	Dry			
Amazilia lactea (Lesson, 1832)	2	0	Nectarivore	UD	I
Trogoniformes					
Trogonidae					
Trogon surrucura Vieillot, 1817	44	11	Omnivore	CA	I
Trogon rufus Gmelin, 1788	2	1	Omnivore	CA	IV
Coraciiformes					
Momotidae					
Baryphthengus ruficapillus (Vieillot, 1818)	136	11	Omnivore	UD	II
Galbuliformes					
Bucconidae					
Malacoptila striata (Spix, 1824)	5	3	Insectivore	UD	I
Piciformes					
Ramphastidae					
Ramphastos toco Statius Muller, 1776	18	4	Frugivore	CA	I
Picidae					
Picumnus albosquamatus d'Orbigny, 1840	23	22	Insectivore	UD	I
Veniliornis passerinus (Linnaeus, 1766)	4	7	Insectivore	UD	I
Piculus flavigula (Boddaert, 1783)	3	1	Insectivore	CA	I
Celeus flavescens (Gmelin, 1788)	2	1	Omnivore	CA	III
Dryocopus lineatus (Linnaeus, 1766)	6	3	Insectivore	CA	I
Campephilus robustus (Lichtenstein, 1818)	6	3	Insectivore	UD	III
Passeriformes					
Thamnophilidae					
Mackenziaena severa (Lichtenstein, 1823)	10	5	Insectivore	UD	I
Thamnophilus caerulescens Vieillot, 1816	70	20	Insectivore	UD	I
Dysithamnus mentalis (Temminck, 1823)	126	25	Insectivore	UD	I
Herpsilochmus rufimarginatus (Temminck, 1822)	74	33	Insectivore	CA	III
Drymophila ferruginea (Temminck, 1822)	81	37	Insectivore	UD	III
Terenura maculata (Wied, 1831)	37	13	Insectivore	CA	III
Pyriglena leucoptera (Vieillot, 1818)	100	25	Insectivore	UD	I
Conopophagidae					
Conopophaga lineata (Wied, 1831)	21	14	Insectivore	UD	II
Rhinocryptidae					
Psilorhamphus guttatus (Ménétriès, 1835)	20	8	Insectivore	UD	I
Dendrocolaptidae					
Sittasomus griseicapillus (Vieillot, 1818)	61	18	Insectivore	UD	III
Xiphocolaptes albicollis (Vieillot, 1818)	3	1	Insectivore	UD	IV
Dendrocolaptes platyrostris Spix, 1825	2	9	Insectivore	UD	IV
Xiphorhynchus fuscus (Vieillot, 1818)	7	3	Insectivore	UD	III
Furnariidae					
Synallaxis ruficapilla Vieillot, 1819	64	29	Insectivore	UD	III
Synallaxis frontalis Pelzeln, 1859	21	10	Insectivore	UD	I
Philydor lichtensteini Cabanis & Heine, 1859	7	3	Insectivore	CA	I

Continue

Table I. Continued.

Species	Season		Habit	Stratum	PD
	Wet	Dry			
Automolus leucophthalmus (Wied, 1821)	15	6	Insectivore	UD	I
Xenops minutus (Sparrman, 1788)	1	3	Insectivore	UD	IV
Xenops rutilans Temminck, 1821	5	0	Insectivore	CA	I
Tyrannidae					
Leptopogon amaurocephalus Tschudi, 1846	27	12	Insectivore	UD	III
Corythopis delalandi (Lesson, 1830)	3	0	Insectivore	UD	III
Hemitriccus orbitatus (Wied, 1831)	130	29	Insectivore	UD	III
Todirostrum poliocephalum (Wied, 1831)	39	31	Insectivore	CA	III
Myiopagis caniceps (Swainson, 1835)	6	6	Insectivore	CA	II
Myiopagis viridicata (Vieillot, 1817)	3	0	Insectivore	UD (M)	III
Camptostoma obsoletum (Temminck, 1824)	21	5	Omnivore	CA	I
Capsiempis flaveola (Lichtenstein, 1823)	25	6	Insectivore	UD	I
Myiornis auricularis (Vieillot, 1818)	107	58	Insectivore	UD	III
Tolmomyias sulphurescens (Spix, 1825)	20	14	Insectivore	CA	III
Platyrinchus mystaceus Vieillot, 1818	5	4	Insectivore	UD	I
Platyrinchus leucoryphus Wied, 1831	1	0	Insectivore	UD	I
Lathrotriccus euleri (Cabanis, 1868)	54	22	Insectivore	UD	III
Colonia colonus (Vieillot, 1818)	8	4	Insectivore	CA	I
Myiodynastes maculatus (Statius Muller, 1776)	30	0	Omnivore	CA (M)	I
Megarynchus pitangua (Linnaeus, 1766)	13	7	Omnivore	CA	I
Empidonomus varius (Vieillot, 1818)	2	0	Omnivore	CA (M)	I
Sirystes sibilator (Vieillot, 1818)	4	0	Insectivore	CA	II
Myiarchus swainsoni Cabanis & Heine, 1859	52	0	Omnivore	CA (M)	III
Myiarchus ferox (Gmelin, 1789)	18	3	Omnivore	CA	I
Pipridae					
Manacus manacus (Linnaeus, 1766)	5	1	Frugivore	UD	I
Chiroxiphia caudata (Shaw & Nodder, 1793)	79	21	Frugivore	UD	III
Tityridae					
Oxyruncus cristatus Swainson, 1821	5	0	Omnivore	CA	III
Schiffornis virescens (Lafresnaye, 1838)	55	15	Omnivore	UD	I
Laniisoma elegans (Thunberg, 1823)	0	1	Omnivore	UD (M)	I
Tityra inquisitor (Lichtenstein, 1823)	0	4	Omnivore	CA	III
Tityra cayana (Linnaeus, 1766)	7	0	Omnivore	CA	I
Pachyramphus polychopterus (Vieillot, 1818)	7	0	Insectivore	CA (M)	III
Vireonidae					
Cyclarhis gujanensis (Gmelin, 1789)	54	24	Insectivore	CA	I
Vireo olivaceus (Linnaeus, 1766)	241	0	Omnivore	CA (M)	III
Corvidae					
Cyanocorax chrysops (Vieillot, 1818)	31	10	Omnivore	UD	III
Turdidae					
Turdus subalaris (Seebohm, 1887)	20	0	Omnivore	UD (M)	I
Turdus leucomelas Vieillot, 1818	0	4	Omnivore	UD	IV
Turdus amaurochalinus Cabanis, 1850	9	1	Omnivore	UD	I

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Table I. Continued.

Species	Season		Habit	Stratum	PD
	Wet	Dry			
Coerebidae					
Coereba flaveola (Linnaeus, 1758)	9	5	Nectarivore	CA	I
Thraupidae					
Nemosia pileata (Boddaert, 1783)	5	8	Omnivore	CA	I
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	14	4	Omnivore	UD	I
Trichothraupis melanops (Vieillot, 1818)	15	28	Omnivore	UD	I
Habia rubica (Vieillot, 1817)	30	24	Omnivore	UD	III
Tachyphonus coronatus (Vieillot, 1822)	9	1	Omnivore	UD	I
Ramphocelus carbo (Pallas, 1764)	30	23	Omnivore	UD	I
Thraupis sayaca (Linnaeus, 1766)	20	8	Omnivore	CA	I
Tangara cayana (Linnaeus, 1766)	10	0	Omnivore	CA	I
Tersina viridis (Illiger, 1811)	7	0	Omnivore	CA	I
Dacnis cayana (Linnaeus, 1766)	9	4	Omnivore	CA	III
Hemithraupis ruficapilla (Vieillot, 1818)	35	15	Omnivore	CA	III
Conirostrum speciosum (Temminck, 1824)	18	17	Omnivore	CA	III
Cardinalidae					
Saltator fuliginosus (Daudin, 1800)	5	1	Frugivore	CA	I
Parulidae					
Parula pitiayumi (Vieillot, 1817)	15	8	Omnivore	CA	I
Basileuterus hypoleucus Bonaparte, 1830	201	49	Insectivore	UD	I
Basileuterus flaveolus (Baird, 1865)	55	7	Insectivore	UD	II
Fringillidae					
Euphonia chlorotica (Linnaeus, 1766)	4	0	Omnivore	CA	III
Euphonia violacea (Linnaeus, 1758)	2	0	Omnivore	CA	III

Table II. Correlations (Spearman) between hour of the day and bird detections, by season and trophic guild, by number of species and total detections. (n.s.) Not significant.

	Wet season (n = 15)		Dry season (n = 13)	
	n	rs	n	rs
Number of Species				
Frugivores	17 –0.53	p< 0.05	13 –0.37	n.s.
Insectivores	46 –0.51	n.s.	39 –0.37	n.s.
Omnivores	32 –0.73	p < 0.01	24 –0.28	n.s.
Canopy	51 –0.75	p < 0.01	35 –0.32	n.s.
Understory	53 –0.61	p < 0.05	47 –0.30	n.s.
Total Detections				
Frugivores	666 –0.60	p < 0.05	136 –0.39	n.s.
Insectivores	1678 –0.69	p < 0.01	615 –0.53	n.s.
Omnivores	806 –0.82	p < 0.01	185 –0.30	n.s.
Canopy	1137 –0.67	p < 0.02	318 –0.36	n.s.
Understory	2045 –0.67	p < 0.02	632 –0.58	p < 0.05

are more pronounced in the tropics than in temperate latitudes (Dawson 1981, Verner & Ritter 1986, Blake 1992). While Blake (1992) found a decline in the number of species and the number of detections, three hours after dawn, while here it was four hours after dawn. Results here suggest that forest communities in different ecosystems may vary in activity patterns, and these differences may arise locally in areas with altitudinal gradients or successional stages (Blake 1992).

Less activity in birds of the understory may be due to low light levels and low temperatures (Mallet-Rodrigues & Noronha 2003). And, with declining light at the end of the day, bird activity increases again, causing the crepuscular activity common elsewhere (Sick 1997). While here a second peak occurred around two hours before dusk, as in other studies, the pattern was similar in the canopy, where both light and temperature are greater, suggesting that other factors determining activity patterns may be important.

These patterns are not explained by migratory birds. Even when a large portion of the community comprises migratory

species, they have little influence on detection patterns (Blake 1992), therefore these daily detection patterns must be due to resident species. Since these patterns are also not merely due to the most abundant species, detection patterns may be considered emergent community patterns.

The wet season is the reproductive period for most species of the forest fragment (Magalhães 1999), because of which vocalization and territory demarcation are common at this time. Thus, this mating activity with its increased vocalization certainly influences detection tendencies for both species and individuals (Best 1981).

Environmental and behavioral factors may be associated with the temporal decline in the number of species and individuals detected along the day. Temperature is greater during the rainy season in this region of Brazil. During the hottest hours several species become inactive (Pizo *et al*. 1997). Also, during the dry season detections decline during the time of day with the highest temperatures (12:00-16:00).

Most species in this forest fragment are monogamous and both sexes participate in incubation and raising young (Sick 1997, Willis & Oniki 2003). Thus, vocalizations (usually songs) may be concentrated during a fixed time of day due to the time spent incubating and foraging to feed young (Sick 1997). Cicadas also sing during this period, especially Cicadidae and Tibicinidae, and during the warmest part of the day, potentially causing sonorous competition between birds and cicadas (Sick 1997).

Food abundance probably declines during the dry season as is the case in other neotropical forests (Davis 1945, Stiles 1980. Pearson & Derr 1986, Levey 1988, Loiselle & Blake 1991, Malizia 2001). The dry season also has the shortest daylengths at this latitude, and so mornings are colder. Perhaps this causes birds to forage more intensively causing greater homogeneity of activity along the day, thus increasing the likelihood of detection. Also, the delay of an hour in activity during the dry season may be due to differences in light and temperature throughout the day that is different between the seasons.

Hourly differences in activity found here as well as the subtle differences among guilds and strata, were not as different between strata as in other studies (Verner & Ritter 1986, Blake 1992). Detection of canopy species throughout the day can vary more than that of understory species and this difference may be due to the greater distances traveled and tendency to travel in groups of canopy birds (Blake 1992). Perhaps a difference is due to that of the methods, point-counts in the case of Blake (1992) and transects as here.

Results here are in agreement with other studies that suggest that bird counts may be limited to the dawn to mid-morning interval (Järvinen *et al*. 1977, Skirvin 1981, Blake 1992, Lynch 1995, Bibby *et al*. 1998). For a more complete species list, however, crepuscular and early evening counts are also important. Perhaps the remainder of the day should be used for other purposes, such as captures (Remsen 1994) where a greater capture rate may occur after 12:00 (Willis & Oniki 2001). Nevertheless, should it be necessary to count birds during the dry season, day-long counts may be more productive than morning counts, at least in seasonal forests.

ACKNOWLEDGEMENTS

Thanks to Edwin O. Willis for his orientation during my graduate studies that resulted in this research, to José Carlos R. de Magalhães for his motivation and support, and José Ragusa Netto for the suggestion to carry out this kind of research. Thanks to annonymous reviewers and Paulo de T. Chaves for suggestions on the earlier version of this manuscript. This study was supported by CNPq.

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Submitted: 09.X.2007; Accepted: 01.VI.2008.
Editorial responsibility: Lena Geise