

## BIRD COMMUNITIES IN FOREST REMNANTS IN THE CITY OF MARINGÁ, PARANÁ STATE, SOUTHERN BRAZIL

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*Resumo.* Comunidades de aves em remanescentes florestais foram estudadas em cinco localidades da cidade de Maringá, Estado do Paraná, Brasil. Os remanescentes amostrados, Parque dos Pioneiros (59 ha), Parque do Ingá (47,3 ha), Horto Florestal Dr. Luiz Teixeira Mendes (37,2 ha), Parque das Perobas (26,3 ha) e Parque Recanto Borba Gato (7,6 ha), constituem manchas da floresta estacional semidecidual em diferentes estágios de sucessão secundária, encontram-se distribuídos em sua maioria no perímetro urbano e estão isolados de outras áreas florestadas maiores. O estudo foi realizado através de levantamento qualitativo utilizando o método do transecto e com amostragens quinzenais. Um total de 144 espécies foram registradas: 57 não-passeriformes, 45 passeriformes suboscines e 42 passeriformes oscines. O Parque do Ingá apresentou a maior riqueza específica (110 espécies) seguido pelo Horto Florestal (91), Parque das Perobas (86), Parque dos Pioneiros (79) e Recanto Borba Gato (74). A maioria das espécies foram residentes (51,4%). A avifauna esteve representada por 81,9% de espécies associadas aos ambientes de floresta e/ou borda de floresta e a categoria trófica melhor representada foi a dos insetívoros (38,2%) seguida pelos onívoros (22,2%). Quando comparado com o Parque Estadual "Mata dos Godoy" observou-se a ausência de representantes de famílias como Trogonidae, Ramphastidae, Rhinocryptidae e Pipridae nos remanescentes amostrados, bem como uma menor representatividade principalmente para espécies das famílias Tinamidae, Psittacidae, Picidae, Dendrocolaptidae, Furnariidae, Formicariidae e Cotingidae. O tamanho da área, o isolamento e a variedade de ambientes foram os principais fatores que determinaram a riqueza de espécies.

*Abstract.* Bird communities were studied in five forest remnants in the city of Maringá, Paraná state, southern Brazil. The sampled remnants, namely Parque dos Pioneiros (59 ha), Parque do Ingá (47.3 ha), Horto Florestal Dr. Luiz Teixeira Mendes (37.2 ha), Parque das Perobas (26.3 ha) and Parque Recanto Borba Gato (7.6 ha), are remnants of seasonal semideciduous forest at different stages of secondary succession, are mostly distributed within city limits, and are isolated from other larger forested areas. The study was developed through a qualitative survey using the transect method and samplings performed twice a month. A total of 144 species were detected: 57 non-passerines, 45 suboscine passerines, and 42 oscine passerines. The Parque do Ingá showed the greatest specific richness (110 species), followed by the Horto Florestal (91 species), the Parque das Perobas (86 species), the Parque dos Pioneiros (79 species) and the Recanto Borba Gato (74 species). Most of the species were resident (51.4%). The avifauna was represented by 81.9% of species associated with forest and/or forest edge environments, and insectivores were the best represented trophic category (38.2%), followed by omnivores (22.2%). As compared to the "Mata dos Godoy" State Park (656 ha), no representative of families such as Trogonidae, Ramphastidae, Rhinocryptidae and Pipridae was found in the sampled remnants, and few representatives of a number of species were detected, mainly from the Tinamidae, Psittacidae, Picidae, Dendrocolaptidae, Furnariidae, Formicariidae and Cotingidae families. Area size, isolation, and variety of environments were the primary factors determining species richness. *Accepted 30 April 2000.*

*Key words:* Forest fragmentation, bird communities, city parks, species richness, Paraná, southern Brazil.

## INTRODUCTION

Coffee and other plantations in red soil have replaced the original seasonal semideciduous forest, since 1935, in northern and western regions of Paraná state, southern Brazil, (Maack 1968). Only 3.4% of the region (8.400.000 ha) is protected in conservation areas (Campos 1996).

Fragmentation of forest ecosystems leads to decrease in species richness and causes changes in the structure and composition of bird communities (Preston 1962, Willis 1974, Forman *et al.* 1976, Galli *et al.* 1976, Leck 1979, Blake 1983, Bierregaard & Lovejoy 1988, Viana 1990, Wilcove & Robinson 1990, Soulé *et al.* 1992, Hamel *et al.* 1993, Aleixo & Vielliard 1995, Anjos 1999). Specialized frugivorous and insectivorous birds, those that are on top of the food chain or those that need large territories, are prone to decline and may disappear (Terborgh 1974, Willis 1979). Bierregaard & Lovejoy (1989) demonstrated that antbirds and birds living in mixed flocks also suffer with forest reduction, losing species before two years of isolation. For Lynch & Whigham (1984), the impacts of fragmentation on the avifauna are complex and species-specific. Although the size of forest remnants is directly related to species loss, other factors such as history of perturbation, area shape, type of vicinity and degree of isolation must also be considered (Viana 1990).

Here we analyze bird communities in five forest remnants in the city of Maringá (23°25'S, 51°25'W), northwestern Paraná state.

## STUDY AREA AND METHODS

The Maringá region was originally semideciduous forest, with rainy summers and dry cool winters. Common trees are *Aspidosperma polyneuron* (Apocynaceae), *Balfourodendron*

*riedelianum* (Rutaceae), *Carimiana estrellensis* (Lecythidaceae), *Cedrela fissilis* (Meliaceae), *Enterpe edulis* (Arecaceae), *Gallsia integrifolia* (Phytolaccaceae), *Holocalyx balansae* (Leguminosae), *Jacaratia spinosa* (Caricaceae), and *Peltophorum dubium* (Leguminosae) (Veloso & Góes-Filho 1982, Leite & Klein 1990).

Five forest remnants were selected for this study: Parque Florestal dos Pioneiros (1, 59 ha), Parque do Ingá (2, 47.3 ha), Horto Florestal Dr. Luiz Teixeira Mendes (3, 37.2 ha), Parque das Perobas (4, 26.3 ha) and Parque Recanto Borba Gato (5, 7.6 ha). All forest remnants constitute vegetation patches in stage of secondary succession, show similar phyto-physiognomic features and are totally isolated from any other forested area (Fig. 1, Table 1).

The mean annual temperature is 20–21°C, mean annual precipitation 1500–1600 mm. The rainiest months are December, January and February, the driest months June, July and August. The city lies at a mean altitude of 555 m a.s.l. (Instituto de Terras Cartografia e Florestas 1987, Milano 1994).

Krügel surveyed birds in the secondary woodland remnants twice a month, from November 1994 to October 1995, except February 1995, for a total of 23 visits each (92 h each area); in February, only one visit was made in each study area due to high rainfall. Pre-determined transects were walked slowly for 4 h, starting 1 h after sunrise. Surveyed habitats were open areas (oa), forests (fo), forest edges (ed), lakes (la) and a streamlet (st). An area was considered open wherever there were lawns, gardens and sparse trees, mainly the Parque do Ingá and Horto Florestal. The other areas comprised remnants of continuous forests. The aquatic environment of area 1 was a streamlet that cuts across the interior of the park while, in areas 2 and 3, there were lakes in the open environments. The lakes covered about 9 ha in area 2, and 0.05 ha in area 3. Species were registered

TABLE 1. Area, distance from city center, open to public visitation or not, habitats and surroundings of each remnant studied.

Locality	Area (ha)	Distance from city center (m)	Public visitation allowed	Habitats <sup>1</sup>	Surroundings
Area 1	59.0	600	No	fo/ed/st	Buildings
Area 2	47.3	560	Yes	fo/ed/oa/la	Buildings
Area 3	37.2	2900	Yes	fo/ed/oa/la	Buildings
Area 4	26.3	9500	No	fo/ed	Buildings and plantations
Area 5	7.6	4200	No	fo/ed	Buildings and plantations

<sup>1</sup>fo = forest, ed = forest edge, oa = open area, la = lakes, st = streamlet.

based on visual (binoculars 8 x 40) and/or auditory contacts.

The feeding category assigned to each species was determined according to the food most often eaten and literature data (Schubart *et al.* 1965, Motta-Júnior 1990, Sick 1997): nectarivores, granivores, frugivores, frugivores/insectivores (mixed diet with a higher proportion of fruit), insectivores/frugivores (mixed diet with a higher proportion of insects), insectivores, omnivores (varied diet that may include seeds, roots, sprouts, leaves, flowers, nectar, fruit, invertebrates, and small vertebrates), insectivores/carnivores (mixed diet with a higher proportion of insects), carnivores/insectivores (mixed diet with a higher proportion of small vertebrates) and carnivores.

The frequency of occurrence was calculated as the percent of months in which each species was detected, divided by 12. Species status was determined according to the distribution of recordings over the year.

Similarity between remnants, using species associated to the forest environment, was assessed by the Sorensen's index of similarity (IS):  $IS = 2S_{ab}/S_a + S_b$ , where  $S_{ab}$  is the number of species in common for locations A and B,  $S_a$  is the number of species in location A, and  $S_b$  is the number of species in B. NTSYS was used for similarity calculations (Rohlf 1989).

## RESULTS

*Richness and composition.* A total of 144 bird species were detected during the survey: 57 non-passerines (39.6%), 45 suboscine passerines (31.2%) and 42 oscine passerines (29.2%). Area 2 showed the highest species richness, 110 species, followed by areas 3 (91), 4 (86), 1 (79), and 5 (74) (Fig. 2). Forest species recorded were 51 for area 1, 47 for area 2, 43 for area 3, 46 for area 4, and 35 for area 5. Fourteen edge species were recorded for area 1, 28 for areas 2 and 3, 27 for area 4, and 25 for area 5. Lake species were 13 for area 2 and 2 for area 3. Open area species were 14 for area 1, 22 for area 2, 18 for area 3, 13 for area 4, and 14 for area 5. Tyrannidae was the best represented family in forest remnants (29 species), followed by Thraupidae (12 species), Formicariidae (6 species) and Fringillidae (6 species). Among non-passeri-form families, Columbidae, Trochilidae and Picidae were best represented (7 species each) (see Appendix).

New species were registered monthly, four (*Harpagus diodon*, *Heliornis fulica*, *Eupetomena macroura* and *Tityra cayana*) for the first time on the last sampling. *Harpagus* and *Tityra* are well known to return in October, and probably were passing through.

The highest similarity indexes were for the pairs 1–2 (0.82). The smallest fragment

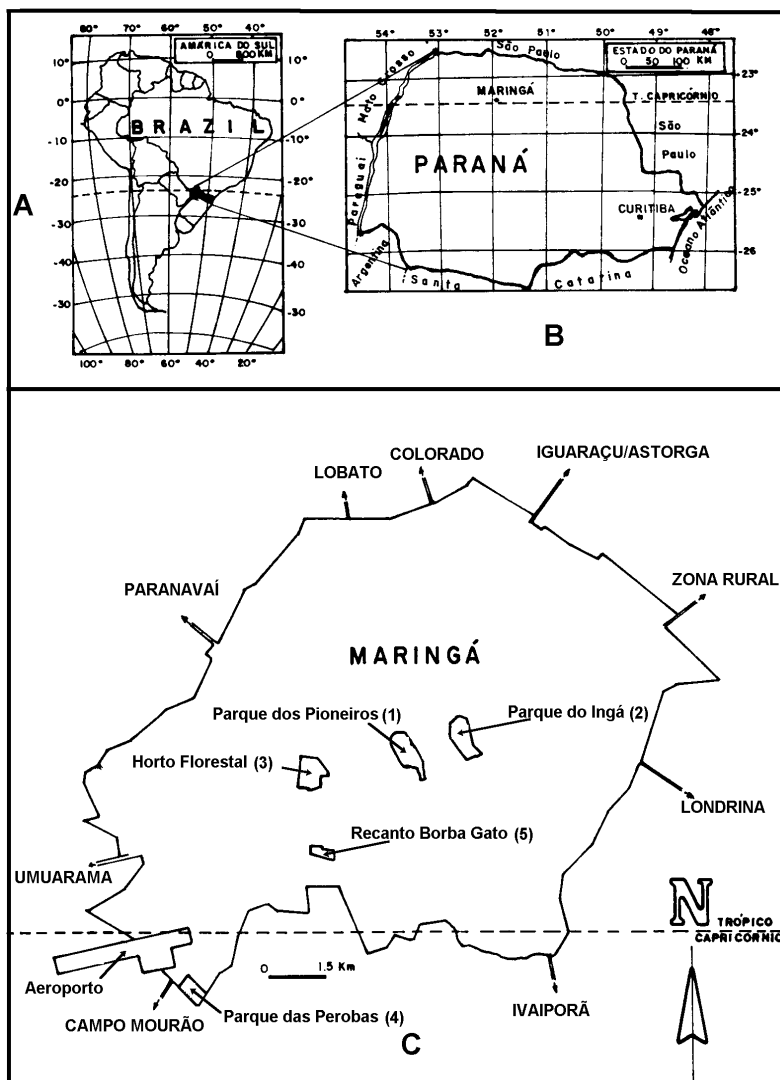


FIG. 1. A: Location of the Paraná state in Brazil; B: Location of the city of Maringá in the Paraná state; C: Location of studied areas in the city of Maringá.

(5) showed the least similarity to area 1 (0.72) (Table 2).

Insectivores were represented by the greatest number of species (35.4–40.7%), followed by omnivores (23–29.1%). Nectarivores were best represented in areas 5 (8.2%) and 2 (7.3%); granivores in area 5 (8.2%); fru-

givores in areas 4 (7.0%) and 1 (5.1%), and carnivores in area 2 (6.4%) (Table 3).

Most of the trophic categories were represented among non-passeriforms. In this group, a predominance of insectivorous species was observed (29.8%), followed by nectarivores, frugivores and carnivores (all with

TABLE 2. Sorensen's index (C<sub>s</sub>) of bird species similarity between forest remnants.

	1	2	3	4
2	0.82			
3	0.77	0.78		
4	0.79	0.79	0.78	
5	0.72	0.75	0.75	0.79

12.3%). Among suboscine passerines, 64.4% of the species were insectivores, and among oscine passerines, 61.9% omnivores.

*Seasonal variation.* The fewest species were found in January, April and June (87, 88 and 89 species, respectively) and the most in October (108 species). Only 73 species were found in February, a month in which only one sampling was performed. The variation in species richness over the year shows that the number of species began to rise in August, peaked in October, and began to decrease in November (Fig. 3). Thirty species were considered as migratory.

*Frequency of occurrence.* Five classes of frequency of occurrence were established: up to 25%,

26–50%, 51–75%, 76–91.6% and 91.7–100% (Table 4).

When all study locations are considered, 50.9% of the community corresponds to species with a frequency of occurrence equal to or above 76%. Among these, 35 species (or 30.7% of the avifauna) were recorded in the twelve months of sampling with a frequency of 100%. At the opposite extreme, 27 species (23.7%) were recorded in three or fewer months of sampling, and 15 (13.1%) were recorded only once. Thirteen species (11.4%) showed a frequency of occurrence of 26–50%, and 16 species (14.0%) from 51 to 75%. Most of the species in the remnants can thus be considered as resident (Table 4).

As remnants are analyzed separately, areas 4 and 5 show a greater percentage of occasional species than of resident ones.

*Habitat distribution.* The resident and/or likely resident species (74 species) that are associated with forest and/or forest edge environments (71) can be divided into three groups: 30 species (40.5%) that are found exclusively in these environments, 30 (40.5%) that occupy open areas secondarily, and 11 species (14.9%) that stay mostly in open areas but

TABLE 3. Number and percentage of species for each guild in studied remnants.

Guilds	Localities				
	Area 1 (%)	Area 2 (%)	Area 3 (%)	Area 4 (%)	Area 5 (%)
Nectarivores	5 (6.3)	8 (7.3)	6 (6.6)	3 (3.4)	6 (8.2)
Granivores	3 (3.8)	4 (3.7)	6 (6.6)	6 (7.0)	6 (8.2)
Frugivores	4 (5.1)	3 (2.7)	4 (4.4)	6 (7.0)	3 (4.0)
Frugivores/insectivores	4 (5.1)	5 (4.5)	4 (4.4)	1 (1.2)	2 (2.7)
Insectivores/frugivores	8 (10.1)	9 (8.2)	7 (7.7)	9 (10.4)	8 (10.8)
Insectivores	28 (35.4)	39 (35.4)	36 (39.5)	35 (40.7)	29 (39.2)
Omnivores	23 (29.1)	28 (25.4)	24 (26.4)	22 (25.6)	17 (23.0)
Insectivores/carnivores	2 (2.5)	3 (2.7)	—	2 (2.3)	1 (1.3)
Carnivores/insectivores	1 (1.3)	4 (3.7)	1 (1.1)	1 (1.2)	1 (1.3)
Carnivores	1 (1.3)	7 (6.4)	3 (3.3)	1 (1.2)	1 (1.3)

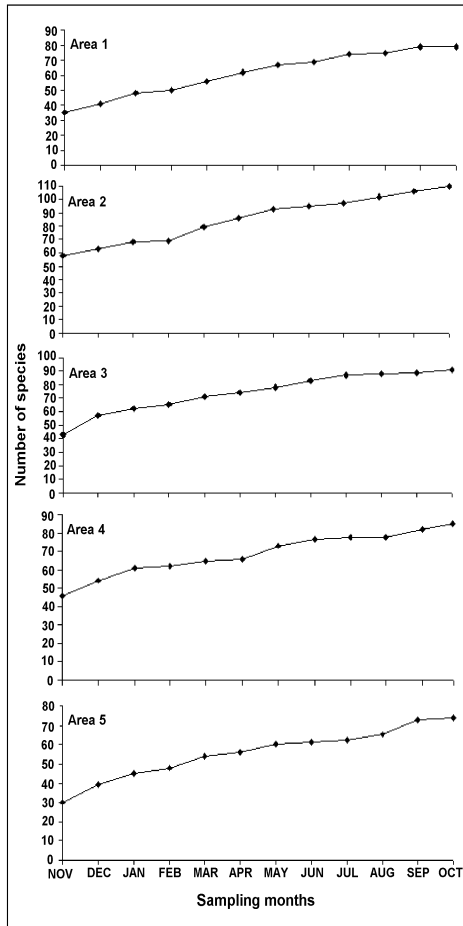


FIG. 2. Cumulative number of species in areas 1 to 5 over the sampling period.

may occasionally visit the forest. The remaining three resident species are strictly related to aquatic environments. Considering the community as a whole, a total of 118 species (81.9%) are, to some extent, associated with forest and forest edge.

DISCUSSION

*Richness, composition and habitat distribution.* Some 413 bird species occur in northwestern Paraná state and boundary regions according

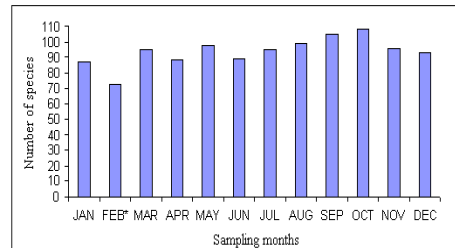


FIG. 3. Seasonal variation of number species over the sampling months. In February (FEB\*), sampling was performed only once in each location.

to Straube *et al.* (1996). However, the species recorded in forest remnants in Maringá correspond to only 34.9% of this number.

Anjos *et al.* (1997) recorded 273 species in the 656 ha "Mata dos Godoy" State Park (PEG), located 25 km south of Londrina and 100 km west of Maringá. The sum of the area of the remnants studied here (177.4 ha) corresponds to only 27% of the PEG's area, partly explaining the far smaller number of species recorded in Maringá. But not only the size of the forest remnants explain the reduction of bird species; the fact that the remnants are in an urban area also contributed for that. By comparing the bird community of the Maringá remnants to the avifauna of the PEG, we can note the absence of such families as Trogonidae, Ramphastidae, Rhinocryptidae and Pipridae. As for other groups of birds that are sensitive to fragmentation of forested areas, such families as Tinamidae, Cracidae, Psittacidae, Picidae, Dendrocolaptidae, Furnariidae, Formicariidae and Cotingidae were poorly represented. The loss of species resulting from the decreased size of fragments becomes evident considering the Dendrocolaptidae family: five species were recorded in the PEG and only one in the three larger remnants (Table 5). According to Forman *et al.* (1976), woodcreepers and woodpeckers may be limited by the number of dead trees available for nesting in forest remnants. The insect-

TABLE 4. Number and percentage of bird species<sup>1</sup> by class of frequency of occurrence<sup>2</sup>.

Locality	Up to 25%	26–50%	51–75%	76–91.6%	91.7–100%
Total	27 (23.7)	13 (11.4)	16 (14.0)	23 (20.2)	35 (30.7)
Area 1	19 (28.7)	7 (10.6)	18 (27.3)	11 (16.7)	11 (16.7)
Area 2	26 (29.2)	17 (19.1)	15 (16.9)	14 (15.7)	17 (19.1)
Area 3	18 (25.7)	15 (21.4)	14 (20.0)	10 (14.3)	13 (18.6)
Area 4	27 (37.0)	13 (17.8)	13 (17.8)	8 (11.0)	12 (16.4)
Area 5	17 (31.0)	12 (21.8)	13 (23.6)	7 (12.7)	6 (10.9)

<sup>1</sup>Migratory species are not included.

<sup>2</sup>Frequency of occurrence (as a percentage) is the number of months during which each species was detected by 12.

tivorous climbers of trunks and branches, which include the Dendrocolaptidae, constitute a characteristic guild of forest ecosystems and are very sensitive to forest fragmentation near Londrina (Soares & Anjos 1999). Only two insectivorous species, *Picumnus temminckii* and *Veniliornis spilogaster*, were recorded in the smallest remnant (5), and were considered as likely residents in this location. The other species representing this guild occurred only in the four larger remnants, except for *Xiphocolaptes albicollis* which was restricted to areas 1 and 2 (see Appendix).

Willis (1979) found that larger parrots, woodcreepers and hawks were absent from forest woodlots of 1,400 ha (Fazenda Barreiro Rico), 251 ha (Mata de Santa Genebra) and 21 ha (UNICAMP). Frugivorous species fell from 9% to 6% of the community in the two smaller woodlots, while omnivores accounted for 27% in the smallest fragment against 23% in the larger ones. The insectivores accounted for 51% in the largest forest and 54% in the other two.

No large hawk was detected in forest remnants over the course of this study. *Buteo maguirostris* was the only resident hawk and, according to Sick (1997), is the most abundant one in Brazil, occurring in cities where

there are enough trees. Three other species were migratory (*Elanoides forficatus*, *Harpagus diodon* and *Ictinia plumbea*) (see Appendix).

As for frugivores, *Pionus maximiliani* was the only parrot observed frequently and exclusively in area 4, the farthest remnant from the city center. Among pigeons, *Columba cayennensis* also occurred only in area 4. As an omnivorous species, *Penelope superciliosus* includes various fruits in its diet. Mikich (1996) notes that this is one of the few guans that can still be found in small forest remnants, playing an important role in fruit consumption and distribution of seeds. The only frugivorous passerine, *Procnias nudicollis*, was occasional in area 1.

Though some passeriforms are susceptible to extinction (Terborgh & Winter, *vide* Harper 1989), antbirds have been considered as especially prone to disappear from areas where continuous forests are fragmented (Terborgh 1974, Willis 1974, Leck 1979, Willis 1979). Few species of this family (6) were detected in the remnants, and they were all insectivorous, often common in secondary vegetation, appearing both inside and at the edge of the forest. Of the three species detected in the smallest remnant (5), only *Thamnophilus caerulescens* was a resident. The other two, *Thamnophilus doliatus* and *Conopo-*

TABLE 5. Comparative chart showing some bird families with a decreased number of species as a result of forest fragmentation.

Taxa	Localities/area (ha)						
	PEG <sup>1</sup> (656)	MSG <sup>2</sup> (251)	1 (59)	2(47.3)	3 (37.2)	4 (26.3)	5 (7.6)
Tinamidae	6	2	—	—	—	1	—
Accipitridae	7	3	2	1	3	1	3
Cracidae	3	1	1	1	—	1	—
Psittacidae	11	4	—	—	1	2	—
Trogonidae	3	—	—	—	—	—	—
Ramphastidae	4	1	—	—	—	—	—
Picidae	11	7	3	3	4	5	2
Dendrocolaptidae	5	—	1	1	1	—	—
Furnariidae	11	4	2	3	2	3	1
Formicariidae	15	3	5	5	2	5	3
Rhinocryptidae	2	—	—	—	—	—	—
Cotingidae	8	2	3	2	1	—	1
Pipridae	5	2	—	—	—	—	—
Tyrannidae	47	27	18	22	22	21	18

<sup>1</sup>PEG = Mata dos Godoy State Park (Data source: Anjos *et al.* 1997).

<sup>2</sup>MSG = Mata de Santa Genebra (Data source: Aleixo & Vielliard 1995).

*phaga lineata*, were detected only once. These species showed a lower frequency possibly because they were represented by few individuals. On the other hand, of the five species observed in the largest remnant, 4 were resident (*Mackenziaena severa*, *Thamnophilus caerulescens*, *Dysithamnus mentalis* and *Conopophaga lineata*), and one was a likely resident (*Herpsilochmus rufimarginatus*). This family was observed to be less well represented in the remnants studied as compared to the PEG, probably due to the size of the Maringá remnants and their state of conservation. Of the 15 species recorded in the PEG, 4 were common in the locations studied: *Conopophaga lineata*, *Dysithamnus mentalis*, *Herpsilochmus rufimarginatus* and *Mackenziaena severa* (Anjos *et al.* 1997). In Santa Genebra, only three antbirds

were recorded: *Thamnophilus doliatus*, *Thamnophilus caerulescens* and *Conopophaga lineata*, the same species observed in area 5. (Aleixo & Vielliard 1995). *Mackenziaena severa*, *Dysithamnus mentalis*, *Herpsilochmus rufimarginatus*, *Hypoedaleus guttatus* and *Drymophila ferruginea* had been present in Santa Genebra earlier but disappeared (Willis 1979, Aleixo & Vielliard 1995).

In addition to the groups cited above, other suboscines are also sensitive to fragmentation. Among the cotingas observed in the study areas, none was resident; three were migratory and all were common in secondary vegetation and at forest edges. Except for *Procnias nudicollis*, the other species recorded were frugivorous/insectivorous. Four species of this family occurred in the larger size rem-



nants (areas 1, 2 and 3), and the only one observed in area 5 was a migratory.

A good many species associated with secondary vegetation, open areas, clearings and forest edges remain abundant and are likely to be increasing in regions with small isolated forest fragments (Leck 1979, Bierregaard & Lovejoy 1989, Bierregaard 1990, Thiollay 1992). Generalist birds, which change their diet from fruit to insects or vice-versa, are also favored in small remnants (Willis 1979). Motta-Júnior (1990) found that the increasing devastation of virgin areas, giving place to secondary forests, may accelerate the replacement of specialized insectivorous and frugivorous birds by omnivores.

Silva & Barreia (1996) failed to detect any specialist frugivorous species in the Parque Horto Municipal de Sorocaba (São Paulo), a 20 ha area, and omnivores and generalist insectivores were the best represented. Galletti (1995), however, notes that omnivores can be effective in distributing seeds and regenerating forests. According to Willis (1979), an increase of omnivores is expected in small fragments, since such birds can compensate for variations in food supply.

The locations showing greater species richness, areas 2 and 3, are different in size but are diverse in habitats. In both we can find forest, open areas and lakes. All aquatic birds that were detected occurred in area 2. Area 1, 4 and 5 are areas of continuous secondary forest. Despite being the largest remnant, area 1 showed fewer species than areas 2 and 3, probably due to the lack of open areas and lakes. In this study, species richness was thus related to environmental variety rather than to remnant size. MacArthur & MacArthur (1961) note that species diversity increases with habitat diversity. However, an area involving 0.3 ha of forest, 0.3 of open area, and 0.3 of lake probably would have low species diversity, even in Maringá.

Sick (1997) claims that oscine passerines

are more characteristic of open areas while suboscine passerines are silvicolous. The latter are more affected by the destruction of forest ecosystems. Areas 1 and 4 sheltered a higher percentage of suboscines because they are made up of forest environment only, a physiognomy that is little appealing to the oscines. Because they are surrounded by plantations, areas 4 and 5 allow that species such as *Volatinia jacarina*, *Sporophila caerulescens*, *Myospiza humeralis*, *Zonotrichia capensis* and *Estrilda astrild*, all associated with open landscapes, approach their edge. Anjos & Boçon (1999) analyzed the avifauna of twelve remnants of mixed temperate rain forest and found that the presence of open area species was more common in smaller remnants than in larger ones.

According to Willis (1979), many flycatchers and oscines are omnivorous and commonly found at forest edges, and they could increase as compared to other suboscines and non-passerines. The results show that among suboscines, the Tyrannidae, totaling 29 species, were best represented in all remnants. Of these, 65.5% are insectivores and 24.1% are insectivores/frugivores. Silva & Barreia (1996) note that flycatchers are abundant in open areas, thus being, among the suboscines, the most susceptible to remain in cutover environments.

*Seasonal variation.* Species richness was greater in August, September and October, due to the presence of migratory species and to the beginning of reproductive activity, which make birds more detectable. On the other hand, a lower richness was found in mid summer (January), autumn (April) and in the first month of the winter (June), a period in which migratory species were absent and birds were quiet, making them difficult to detect.

In this region, autumn and winter are mild. Mean temperatures (at 11 a.m.) in autumn were 27.3 °C, 23.4 °C and 20.8 °C

(March, April and May, respectively) and 21.9 °C, 23.2 °C e 25.2 °C in winter (June, July and August, respectively). The small rise in temperature from June to July, beside others possible factors as day length and rain cycle, seems to trigger reproductive activity, as, from July to October, there was a steady increase in the number of detected species.

The seasonal variation of the avifauna in the present study was similar to that found by Anjos & Graf (1993) in the upland region of Campos Gerais (Paraná), where the species richness was greater September to November, October being the richest (220 species).

*Frequency of occurrence.* Considering all study locations, a total of 58 species were considered as resident – should be analyzed carefully; the number of resident species must have been greater due to birds' less noticeable behavior in certain periods of the year and/or difficulty in detecting them. Accordingly, *Crypturellus parvirostris* and *Dromococcyx pavoninus*, among others, were likely resident species, even though they were recorded only once due to difficulty in detection. Of the total 144 species, it is estimated that 51.4% were resident species, 20.8% were migratory, and 18.8% were occasional. This estimate was based on the literature (Belton 1994, Sick 1997, Ridgely & Tudor 1994a, b) and on the distribution of occurrence, observing whether the species were consistently detected in all seasons of the year.

The results obtained in areas 4 and 5 (the smallest remnants) are in agreement with studies by Aleixo & Vielliard (1995) in the Mata de Santa Genebra, a 251 ha forest remnant in the city of Campinas (São Paulo) where most of the birds recorded (44%) were species with a frequency of occurrence below 25% against 26% of species with a frequency equal to or above 76%.

*Conservation.* All forest remnants included in

this study are protected by municipal laws. Nevertheless, they still suffer progressive degradation due to isolation which, in the long run, jeopardizes the survival of several species.

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APPENDIX. Localities, habitats, frequency of occurrence, guilds and status of bird species recorded in forest remnants. Sequence and nomenclature follow Meyer de Schauensee (1982).

Taxa	Localities <sup>1</sup>	Habitats <sup>2</sup>	Frequency of occurrence <sup>3</sup>	Guild <sup>4</sup>	Status <sup>5</sup>
Tinamidae					
<i>Crypturellus parvirostris</i> *	4	ed/fo	8.3	7	OC
Podicipedidae					
<i>Podiceps dominicus</i> *	2	la	41.6	7	US
Phalacrocoracidae					
<i>Phalacrocorax brasilianus</i>	2	la	91.6	10	SS
Ardeidae					
<i>Casmerodius albus</i>	2,3	la	91.6	10	SS
<i>Egretta thula</i>	2	la	50.0	10	US
<i>Butorides striatus</i>	2	la	58.3	9	M
<i>Bubulcus ibis</i> *	2	la	41.6	6	US
<i>Nycticorax nycticorax</i>	2	la	33.3	9	US
Cathartidae					
<i>Coragyps atratus</i> *	1,2,3,4,5	ed/oa	100.0	10	SS
Accipitridae					
<i>Elanoides forficatus</i> *	1,5	fo(s)	16.6	5	M
<i>Harpagus diodon</i>	3	fo	8.3	6	M
<i>Ictinia plumbea</i>	3,5	ed	50.0	6	M
<i>Buteo magnirostris</i> *	1,2,3,4,5	ed/ao	100.0	9	SS
Falconidae					
<i>Polyborus plancus</i>	2,3,4,5	ed/oa	66.6	7	LR
Cracidae					
<i>Penelope superciliosus</i> *	1,2,4	fo/ed	58.3	7	LR
Rallidae					
<i>Aramides saracura</i> *	1,2,3,4	fo/ed/la	66.6	7	LR
Heliornithidae					
<i>Heliornis fulica</i> *	2	la	8.3	8	OC
Jacaniidae					
<i>Jacana jacana</i> *	2	la	8.3	9	OC

APPENDIX. Continuation.

Taxa	Localities <sup>1</sup>	Habitats <sup>2</sup>	Frequency of occurrence <sup>3</sup>	Guild <sup>4</sup>	Status <sup>5</sup>
Charadriidae					
<i>Vanellus chilensis</i>	2	oa	41.6	6	US
Columbidae					
<i>Columba picazuro*</i>	1,2,3,4,5	ed	100.0	3	SS
<i>Columba cayennensis</i>	4	fo	41.6	3	US
<i>Zenaida auriculata*</i>	1,2,3,4,5	ed/oa	100.0	2	SS
<i>Columbina talpacoti</i>	1,2,3,4,5	ed/oa	100.0	2	SS
<i>Columbina picui</i>	2,3,4,5	ed/oa	91.6	2	SS
<i>Leptotila verreauxi*</i>	1,2,3,4,5	fo/ed	91.6	3	SS
<i>Leptotila rufaxilla*</i>	1,2,3,4,5	fo/ed	91.6	3	SS
Psittacidae					
<i>Aratinga leucophthalmus</i>	3	ed(s)	8.3	3	OC
<i>Pionus maximiliani*</i>	4	fo/ed	41.6	3	US
<i>Amazona aestiva*</i>	4	fo	8.3	3	OC
Cuculidae					
<i>Coccyzus melacoryphus</i>	2,3,4,5	ed/fo	16.6	6	M
<i>Piaya cayana</i>	1,2,3,4,5	fo/ed/oa	100.0	6	SS
<i>Crotophaga ani</i>	1,2,3,4,5	ed/oa	100.0	6	SS
<i>Guira guira</i>	2,3,4,5	ed/oa	66.6	6	LR
<i>Tapera naevia*</i>	1,4,5	ed/fo	58.3	8	LR
<i>Dromococcyx pavoninus*</i>	2	fo	8.3	8	OC
Nyctibiidae					
<i>Nyctibius griseus*</i>	2	ed	8.3	6	OC
Caprimulgidae					
<i>Nyctidromus albicollis*</i>	4	ed	25.0	6	OC
<i>Caprimulgus sp.*</i>	2	ed	8.3	6	OC
Apodidae					
<i>Chaetura cinereiventris</i>	3,5	fo(s)	33.3	6	M
Trochilidae					
<i>Phaethornis pretrei</i>	1,2,3,4,5	fo/ed/oa	91.6	1	SS
<i>Eupetomena macroura</i>	2	oa	8.3	1	OC
<i>Melanotrochilus fuscus</i>	1,2,3,5	ed/fo/oa	58.3	1	M
<i>Anthracothorax nigricollis</i>	2,3,5	oa/ed/fo	50.0	1	M
<i>Chlorostilbon aureoventris</i>	1,2,3,4,5	oa/fo/ed	100.0	1	SS
<i>Hylocharis chrysura</i>	1,2,3,4,5	ed/oa/fo	100.0	1	SS
<i>Amazilia lactea</i>	1,2,3,5	ed/oa/fo	91.6	1	SS
Alcedinidae					
<i>Ceryle torquata</i>	2,3	la	91.6	10	SS
<i>Chloroceryle amazona*</i>	2	la	25.0	10	OC
<i>Chloroceryle americana*</i>	2	la	8.3	10	OC
Momotidae					
<i>Baryphthengus ruficapillus</i>	1,3,4,5	fo/ed	91.6	6	SS
Picidae					
<i>Picumnus temminckii</i>	1,2,3,4,5	fo/ed	100.0	6	SS
<i>Colaptes campestris</i>	4	ed/oa	25.0	6	OC

## APPENDIX. Continuation.

Taxa	Localities <sup>1</sup>	Habitats <sup>2</sup>	Frequency of occurrence <sup>3</sup>	Guild <sup>4</sup>	Status <sup>5</sup>
<i>Celus flavescens</i>	1,3,4	fo/ed	58.3	5	LR
<i>Dryocopus lineatus</i>	3	ed	8.3	6	OC
<i>Melanerpes flavifrons</i>	2	ed	25.0	5	OC
<i>Leuconerpes candidus*</i>	4	ed	16.6	5	OC
<i>Veniliornis spilogaster</i>	1,2,3,4,5	fo/ed/oa	100.0	6	SS
Dendrocolaptidae					
<i>Sittasomus griseicapillus</i>	3	fo/ed	66.6	6	LR
<i>Xiphocolaptes albicollis</i>	1,2	fo	41.6	6	US
Furnariidae					
<i>Furnarius rufus</i>	2,4	oa/ed	100.0	6	SS
<i>Synallaxis frontalis</i>	1,2,3,4,5	fo/ed	100.0	6	SS
<i>Xenops rutilans</i>	1,2,3,4	fo/ed	91.6	6	SS
Formicariidae					
<i>Mackenziaena severa</i>	1,2,4	fo/ed	100.0	8	SS
<i>Thamnophilus doliatus</i>	2,4,5	fo/ed	75.0	6	LR
<i>Thamnophilus caerulescens</i>	1,2,3,4,5	fo/ed	100.0	6	SS
<i>Dysithamnus mentalis</i>	1,2,3,4	fo/ed	100.0	6	SS
<i>Herpsilochmus rufimarginatus</i>	1	fo	66.6	6	LR
<i>Conopopbaga lineata</i>	1,2,4,5	fo/ed	100.0	6	SS
Cotingidae					
<i>Pachyramphus polychopterus*</i>	1	fo/ed	8.3	4	M
<i>Platypsaris rufus</i>	2	ed/oa	58.3	4	M
<i>Tityra cayana</i>	5	fo	8.3	4	M
<i>Tityra inquisitor</i>	1,2,3	fo/ed/oa	58.3	4	LR
<i>Procnias nudicollis*</i>	1	fo	8.3	3	OC
Tyrannidae					
<i>Colonia colonus</i>	1,2,3,4,5	fo/ed/oa	91.6	6	SS
<i>Pyrocephalus rubinus</i>	3,5	oa/ed	25.0	6	M
<i>Machetornis rixosus</i>	1,2,4	oa/ed	58.3	6	LR
<i>Muscivora tyrannus</i>	1,2,3,4,5	oa/ed	58.3	5	M
<i>Tyrannus melancholicus</i>	1,2,3,4,5	oa/ed	83.3	5	M
<i>Empidonax varius</i>	1,2,3,4,5	oa/ed/fo	66.6	5	M
<i>Megarhynchus pitangua</i>	1,2,3,4,5	ed/fo/oa	100.0	6	SS
<i>Myiodynastes maculatus</i>	1,2,3,4,5	fo/ed/oa	66.6	5	M
<i>Myiozetetes similis</i>	1,2,3	oa/ed/fo	91.6	4	SS
<i>Pitangus sulphuratus</i>	1,2,3,4,5	oa/fo/ed	100.0	7	SS
<i>Pseudattila phoenicurus</i>	3	ed/oa	25.0	6	M
<i>Myiarchus swainsoni</i>	2,3,4,5	ed/fo	75.0	5	M
<i>Empidonax euleri</i>	2,3,5	fo/ed	50.0	6	M
<i>Cnemotriccus fuscatus*</i>	3,4	ed	16.6	6	OC
<i>Myiophobus fasciatus</i>	2,4,5	ed	58.3	6	LR
<i>Todirostrum cinereum</i>	1,2,3,4,5	ed	100.0	6	SS
<i>Todirostrum plumbeiceps</i>	2,4,5	fo/ed	91.6	6	SS
<i>Myiornis auricularis</i>	1,2,3,4,5	fo/ed	100.0	6	SS
<i>Phylloscartes ventralis</i>	3	fo/ed	8.3	6	OC

APPENDIX. Continuation.

Taxa	Localities <sup>1</sup>	Habitats <sup>2</sup>	Frequency of occurrence <sup>3</sup>	Guild <sup>4</sup>	Status <sup>5</sup>
<i>Capsiempis flaveola</i>	1,2,4	fo/ed	50.0	6	US
<i>Euscarthmus meloryphus</i> *	4	ed	33.3	6	US
<i>Serpophaga subcristata</i>	1,3,4,5	ed/oa/fo	58.3	6	LR
<i>Elaenia flavogaster</i>	1,2,3,4,5	ed/oa/fo	91.6	4	SS
<i>Elaenia parvirostris</i>	2	ed	16.6	5	M
<i>Myiopagis caniceps</i>	1,2,3,4,5	fo/ed	91.6	5	SS
<i>Myiopagis viridicata</i>	1,2,3,4,5	fo/ed	75.0	6	M
<i>Camptostoma obsoletum</i>	3	ed/oa	41.6	6	US
<i>Phyllomyias fasciatus</i> *	1,2	ed/fo	16.6	6	OC
<i>Leptopogon amaurocephalus</i>	1,2,3,4	fo/ed	100.0	6	SS
Hirundinidae					
<i>Tachycineta albiventer</i>	2	la	66.6	6	M
<i>Progne chalybea</i>	1,2,3,4,5	oa(s)	41.6	6	M
<i>Notiochelidon cyanoleuca</i>	1,2,3	oa(s)	91.6	6	SS
<i>Stelgidopteryx ruficollis</i>	2	ed(s)	16.6	6	M
Corvidae					
<i>Cyanocorax chrysops</i>	1,2	fo/ed	91.6	7	SS
Troglodytidae					
<i>Troglodytes aedon</i>	1,2,3,4,5	oa/ed	100.0	6	SS
Turdidae					
<i>Turdus nigriceps</i> *	1,2,3,4,5	fo	16.6	7	M
<i>Turdus rufiventris</i>	1,2,3,4	fo/ed/oa	100.0	7	SS
<i>Turdus leucomelas</i>	1,2,3,4,5	fo/ed/oa	100.0	7	SS
<i>Turdus amaurochalinus</i>	1,2,3,4,5	fo/ed/oa	91.6	7	SS
<i>Turdus albicollis</i>	1,2,3,4	fo/ed	41.6	7	M
Vireonidae					
<i>Cyclarhis gujanensis</i>	1,2,3,4,5	fo/ed	100.0	6	SS
<i>Vireo olivaceus</i>	1,2,4,5	fo/ed	50.0	5	M
Icteridae					
<i>Molothrus bonariensis</i>	1,2,3,4,5	oa/ed	50.0	7	M
<i>Scaphidura oryzivora</i> *	2	oa	8.3	7	OC
<i>Cacicus haemorrhous</i>	2	ed	83.3	7	SS
Parulidae					
<i>Parula pitiayumi</i>	1,2,3,4,5	fo/oa/ed	91.6	6	SS
<i>Basileuterus culicivorus</i>	1,2,3,4,5	fo/ed	100.0	6	SS
Coerebidae					
<i>Coereba flaveola</i> *	2	oa	16.6	1	OC
<i>Conirostrum speciosum</i>	1,2,3,4,5	fo/ed/oa	100.0	5	SS
<i>Dacnis cayana</i>	1,2,3,4,5	fo/oa/ed	100.0	7	SS
Tersinidae					
<i>Tersina viridis</i> *	2,3	ed/fo	25.0	4	M
Thraupidae					
<i>Euphonia musica</i>	1,2,3,5	fo/ed/oa	16.6	7	OC
<i>Euphonia chlorotica</i>	1,2,3,4,5	fo/ed/oa	100.0	7	SS
<i>Euphonia violacea</i>	2	ed	8.3	7	OC

## APPENDIX. Continuation.

Taxa	Localities <sup>1</sup>	Habitats <sup>2</sup>	Frequency of occurrence <sup>3</sup>	Guild <sup>4</sup>	Status <sup>5</sup>
<i>Euphonia pectoralis</i>	1,2,3	fo/ed/oa	58.3	7	LR
<i>Pipraeidea melanonota</i>	1,3,4	fo/ed/oa	33.3	7	US
<i>Thraupis sayaca</i>	1,2,3,4,5	oa/ed/fo	91.6	7	SS
<i>Thraupis bonariensis</i> *	2,3	oa/ed	16.6	7	OC
<i>Habia rubica</i>	1,2,3,4	fo/ed	100.0	7	SS
<i>Tachyphonus coronatus</i>	1	fo/ed	16.6	7	OC
<i>Trichothraupis melanops</i>	1,2,3,4,5	fo/ed	100.0	7	SS
<i>Nemosia pileata</i>	2,3,4,5	ed/oa	66.6	6	LR
<i>Hemithraupis guira</i>	1,2,3,4,5	fo/ed/oa	100.0	7	SS
Fringillidae					
<i>Saltator similis</i>	1,2,3,4,5	fo/ed/oa	100.0	7	SS
<i>Volatinia jacarina</i>	3,4,5	ed/oa	66.6	2	M
<i>Sporophila caeruleascens</i>	1,2,3,4,5	oa/ed	83.3	2	SS
<i>Coryphospingus cucullatus</i>	3,4,5	ed/fo	66.6	7	LR
<i>Myospiza humeralis</i>	5	ed/oa	16.6	7	OC
<i>Zonotrichia capensis</i>	2,3,4	oa/ed	91.6	7	SS
Ploceidae					
<i>Passer domesticus</i>	1,2,3,5	oa/ed	100.0	7	SS
Estrildidae					
<i>Estrilda astrild</i>	3,4,5	ed/oa	41.6	2	US

\* Species whose feeding behavior is based on literature information.

<sup>1</sup>Localities: 1 = Parque dos Pioneiros, 2 = Parque do Ingá, 3 = Horto Florestal, 4 = Parque das Perobas, and 5 = Recanto Borba Gato.

<sup>2</sup>Lists the habitat(s) where the species was detected, in decreasing order of significance or use by the species: la = lakes, oa = open area, fo = forest, ed = forest edge. The "s" indicates that the species flew over a given habitat and no other kind of interaction was observed.

<sup>3</sup>Frequency of occurrence: as a percentage, is the number of months in which the species was detected divided by 12, including all of the remnants.

<sup>4</sup>Guilds: 1 = Nectarivores, 2 = granivores, 3 = frugivores, 4 = frugivores/insectivores, 5 = insectivores/frugivores, 6 = insectivores, 7 = omnivores, 8 = insectivores/carnivores, 9 = carnivores/insectivores, 10 = carnivores.

<sup>5</sup>Status: Occasional (OC), unclear status (US), likely resident (LR), sedentary species (SS), migratory species (M). Species status was determined according to the distribution of recordings over the year.