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Avian assemblages in bamboo and non-bamboo habitats in a tropical rainforest

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Abstract. Some species of bird are closely associated with bamboos (bamboo specialists) but community-wide studies comparing the avian assemblages in bamboo and non-bamboo habitats are lacking. Using point counts, we compared the species richness, abundance and composition of the avian assemblages in bamboo and non-bamboo habitats in the Brazilian Atlantic forest. Apart from considering bamboo specialists and non-specialist species, we contrasted birds from different categories of forest dependence, forest strata and diet. We recorded a total of 81 species of birds (74 in bamboo, 55 in non-bamboo habitats), including 15 bamboo specialists. Species richness was greater in bamboo habitats in all categories of diet and forest dependence. Bamboo and non-bamboo habitats had a similar number of canopy species, but bamboo habitats had a greater number of non-canopy species. The abundance of the whole avian community or of each of the dietary categories did not differ between habitats. The overall species composition differed between habitats, with a more homogeneous composition in non-bamboo habitats. A great number of species use bamboo habitats, even if they are not bamboo specialists. The initial expansion of bamboos, forming discrete patches of bamboo within mature forest, represents an intermediate-level disturbance that enhances forest heterogeneity and promotes the diversity of avian communities.

Additional keywords: Atlantic forest, Brazil, diet, forest dependence, forest strata, intermediate-disturbance hypotheses.

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Introduction

Bamboos form distinct microhabitats in forests around the world (Stotz *et al*. 1996; Judziewicz *et al*. 1999). The particular architecture and growth form of bamboos can profoundly change the local vegetation structure, alter forest dynamics and regeneration and reduce the diversity of plant species (Oliveira-Filho *et al*. 1994; Guilherme *et al*. 2004; Fantini and Guries 2007). The massive seed production of bamboos and colonisation by vegetative reproduction are characteristics that allow bamboos to become dominant in forests, forming distinct and sometimes extensive patches. In south-western Amazonia, for example, ~180 000 km^2 of forest are dominated by the bamboos *Guadua weberbaueri* and *G. sarcocarpa* (Nelson 1994; Griscom and Ashton 2003).

Despite their effect on forest structure and function, bamboos provide foraging opportunities for insectivorous and granivorous birds, some of which are closely associated with bamboos and are considered bamboo specialists. Insectivores may find a variety of prey items in suspended dead leaves, in cavities in bamboos and along the culms and foliage of bamboos (Kratter 1997; Díaz *et al*. 2005). Granivores profit from the massive production of seeds that characterise bamboo reproduction (Janzen 1976), typically tracking bamboo reproductive episodes (Areta *et al*. 2009). For the lowland and montane Atlantic forests of the Neotropical region, Stotz *et al*. (1996) respectively listed 19 and 24 bird species typical of bamboo-dominated microhabitats, but other species of these forests may also be considered bamboo specialists (Bodrati *et al*. 2010; Santana and Anjos 2010). In the Amazonian region, 18 of 474 bird species recorded in Alta Floresta, Brazil, were confined to bamboo patches (Zimmer *et al*. 1997), and at the Tambopata Reserve, Peru, 25 bird species were confined to forest patches dominated by the giant bamboo *G. weberbaueri* (Kratter 1997). In the Tambopata Reserve, bamboo-dependent birds were a significant part (6%) of the total bird community (Kratter 1997).

To date, studies of the relationship of birds with bamboos have focussed on subsets of the avian community, especially understorey insectivores and granivores (Reid *et al*. 2004; Santana and Anjos 2010). Frugivores have been neglected despite their importance for the successful colonisation of bamboo patches by non-bamboo plant species (Rother *et al*. 2009). However, patches dominated by bamboos may be unattractive to frugivorous birds because bamboos do not produce fleshy fruits.

Possibly facilitated by anthropogenic disturbance (e.g. logging, harvesting of palm (*Euterpe edulis*) hearts) and natural disturbances (e.g. landslides, gaps resulting from tree falls), the native bamboo *Guadua tagoara* dominates large areas of the Atlantic forest in south-eastern Brazil, with an estimated total area of ~15 000 ha, and is considered a management problem inside forest reserves (Alves 2007; Lima *et al*. 2012). The growth of its rhizomes permits the formation of discrete patches (genets) whose fusion may lead to the dominance of large expanses of forest (Makita 1998). The dominance of *G. tagoara* exerts a strong influence on vegetation dynamics, damaging trees and saplings, changing the forest microclimate, promoting high rates of litter deposition and a discontinuous canopy (Alves 2007; Fantini and Guries 2007). However, there have been no studies examining the effect that the dominance of bamboos and the consequent alteration of forest structure might have on faunal assemblages. Such study is needed to determine if bamboo is a problem within forest reserves.

In this study, we compare the species richness, abundance and composition of the avian assemblages in bamboo and non-bamboo habitats of the Brazilian Atlantic forest. We seek to determine if bamboo is a threat to avian communities or an important element that, by favouring the presence of bamboo specialists, enhances community diversity. Besides distinguishing bamboo specialists and non-specialists species, we compared birds with different levels of forest dependence, and specialising in different forest strata and dietary categories.

Methods

Study site

Field-work was conducted in the lowlands of the Parque Estadual Carlos Botelho (Carlos Botelho State Park; 24°00′–24°15′S, 47°45′–48°10′W), in the state of São Paulo, south-eastern Brazil. The average annual temperature is 21.1°C (range 17.4–25.2°C), and average annual rainfall is ~2000 mm. Rainfall occurs throughout the year, but December–March are wetter and hotter than the rest of the year (DAEE/SP 2009). The reserve contains >37 000 ha of well-preserved Atlantic rainforest (*sensu* Morellato and Haddad 2000). Combined with other adjacent reserves, the park forms a continuous block of 120 000 ha of forest, one of the largest in the whole Atlantic forest. The study site comprises tall (20–30 m) lowland old-growth forest with a wet and shady understorey where palms (*Euterpe edulis*, *Geonoma* spp.) and arborescent ferns (*Alsophila* spp., *Cyathea* spp.) are common. Myrtaceae, Lauraceae, Rubiaceae, Fabaceae and Sapotaceae are the most species-rich plant families (Lima *et al*. 2011).

Within the rainforest of the study site, patches of the bamboo *Guadua tagoara* (Nees) Kunth, a large (culms may reach 10–15 m; Alves 2007), semi-scandent, native woody bamboo of the Brazilian Atlantic rainforest, are interspersed among forest with no bamboo (of any species) forming a mosaic. The patches of bamboo varied in shape and size (400–20 000 m^2), and occurred on more clay soils. Although dominated by bamboos, some patches of bamboo have trees that remained following the expansion of bamboo and others that grew amid the bamboos forming a discontinuous canopy, with larger gaps between tree crowns. As a result, patches of bamboo have lower density and basal area of trees >5-cm diameter at breast height (DBH) (Lima *et al*. 2012). In addition, patches of bamboos have thicker ground-litter than non-bamboo patches (Rother 2006). Some trees, however, remain following the expansion of bamboo and others will grow amid the bamboos. A survey of trees with DBH $\geq$5 cm in 80 circular plots of 10-m radius in bamboo and non-bamboo habitats (40 plots in each) recorded average densities ($\pm$s.d.) of 1007.5 $\pm$ 541.8 trees ha^{-1} (139 species) in bamboo patches and 1278.8 $\pm$ 541.8 trees ha^{-1} (153 species) in non-bamboo patches (D.C. Rother, unpubl. data). The last reproductive episode of *G. tagoara* in the study area was in 2004, and at the time of our study (2008–09), no seeds were present. The high density of bamboo culms in the understorey of bamboo patches makes it very hard to traverse such patches.

Census data

We collected data from the mosaic of bamboo and forest, sampling both patches of bamboo and non-bamboo habitat. We conducted 10-min point counts of all birds seen or heard within a 30-m radius; this radius allowed sampling within the limits of the smallest patches of bamboo. Five census points were placed at random in patches of bamboo and in non-bamboo habitat, with at least 100 m between neighbouring points. The five points in each habitat were sampled once each month from May 2008 to April 2009 (except October 2008 owing to weather conditions) between 0600 and 0900 hours. Only diurnal birds were considered in this study. All counts were done by one author (K. J. F. Alves).

Birds were classified according to diet, dependence on forested habitats and the forest strata most frequently used. Because dietary studies were lacking for most species, we used only broad categories of diet to reduce the probability of erroneous assignment of dietary class, based on published literature (Moojen *et al*. 1941; Schubart *et al*. 1965) and personal observations of the authors. Species were classed as frugivores, insectivores, nectarivores, or granivores; the latter were species for which seeds, either from fleshy or dry fruits, formed an important part of the diet. No carnivores were detected. Forest dependence was based mostly on Silva (1995), with a few modifications based on personal observations of the authors. Categories of forest dependence were: (1) dependent, species found mainly in forest habitats; (2) semi-dependent, species occurring in forest but also often found in open habitats and (3) independent, species that do not need forest, and are often found in open vegetation such as pastures and grasslands, although usually with scattered trees. Lastly, forest-dependent species only were classified based on the forest strata most frequently used (based on personal observations of the authors in the study site and other areas of Atlantic forest): canopy (>8 m above ground), midstorey (~4–8 m above ground) or understorey (<4 m above ground).

We determined the bird species typically associated with bamboo in the Atlantic Forest based on published literature (Ridgely and Tudor 1994; Stotz *et al*. 1996; Santana and Anjos 2010). Nomenclature and arrangement of bird species follows the South American Classification Committee of the American Ornithologists' Union (Remsen *et al*. 2011).

Statistical analyses

To compare numbers of bird species in bamboo and non-bamboo habitats we determined several estimators of species richness (Chao 2, Jackknife 1, Jackknife 2, Bootstrap). We used the *specpool* function in the vegan library within the software R (version 2.9.2; R Development Core Team 2009), which estimates the extrapolated species richness in a species pool, or the number of unobserved species. Function *specpool* is based on the incidence of species in sample sites (point counts in our case) and gives a single estimate for a collection of sampling sites (data matrix).

Rarefaction analyses were used to compare bamboo and non-bamboo habitats in relation to the total number of bird species, and the number of bird species within each category of diet, forest dependence and forest strata. For forest strata, we pooled mid-storey and understorey categories because several birds often use these two strata interchangeably. Rarefaction analyses are useful to deal with possible sampling effects in the estimation of species richness, which in our case may lead to erroneous estimates of richness for a given habitat simply owing to greater avian abundance in that particular habitat (Gotelli and Colwell 2001). Therefore, in every comparison where this was possible, we 'rarefied' the larger abundance to the lowest abundance level and then compared species richness. Rarefaction analyses were based on 95% confidence intervals (CI) derived from 1000 permutations implemented in EcoSim 7.0 (Gotelli and Entsminger 2001).

Rank-abundance plots were used to graphically depict the abundance distributions of birds in bamboo and non-bamboo habitats (Magurran 1988). In addition, monthly and inter-habitat variation in abundance of the whole avian community and of each of the dietary categories were tested with repeated-measures analysis of variance (ANOVA) implemented with the GLM module of Statistica 6.0 (StatSoft 1999). For these analyses data were transformed to log + 1.

Analyses of similarity (ANOSIM) were performed to compare habitats in relation to the similarity in the composition of the whole avian community, and also the species composition in each diet category except nectarivores, which had few species recorded. ANOSIM is a permutation procedure that uses a test statistic (R) to compare the level of similarity between and within groups (bamboo and non-bamboo habitats in our case; Clarke 1993; Clarke and Warwick 1998). R ranges from –1 to +1. Differences between groups are suggested by R values >0, indicating that bird assemblages were more dissimilar between groups than within groups. We used the Morisita index as the measure of similarity. The significance of R was determined by comparison with the values obtained by 10 000 randomisations implemented in the software PAST (version 1.81; Hammer *et al.* 2001). We also used PAST to produce a non-metric multidimensional scaling (NMDS) biplot that graphically represented the bird similarity among point counts; points that are closer in the biplot are more similar in terms of species composition (McCune and Grace 2002). NMDS was performed upon a similarity matrix (based on Morisita index) of bird species among point counts.

Results

A total of 81 species of birds, 74 in bamboo habitats and 55 in non-bamboo habitats, were recorded, including 15 species often associated with bamboos (Table 1, Appendix 1). Different estimators were consistent in indicating higher species richness for bamboo habitats compared with non-bamboo habitats (Table 2). Rarefaction curves did not reach an asymptote for either bamboo or non-bamboo habitats (Fig. 1). Indeed, the total number of species recorded represents approximately one-third of the avifauna recorded so far at Carlos Botelho (excluding nocturnal species and species associated with open and aquatic environments; Antunes *et al.* 2006).

Most of the bird species recorded were insectivores (57% of all species), followed by frugivores (23%), granivores (15%) and nectarivores (5%; Appendix 1). For all dietary categories, a greater number of species was recorded in bamboo habitats than non-bamboo habitats; this was pronounced for insectivores (Table 1). Forest-dependent species were by far the most commonly recorded category of forest dependence (80%), followed by semi-dependent (15%) and independent species (5%, Appendix 1). For all categories of forest dependence, species richness was greater in bamboo habitats than non-bamboo habitats (Table 1). The understorey was the forest stratum most commonly used by forest-dependent species (41%, $n = 65$), followed by the midstorey (34%) and the canopy (25%; Appendix 1).

Table 1. Species richness and abundance of birds in bamboo and non-bamboo habitats

Birds were categorised according to the diet, forest dependence and forest strata (see text for definitions). Rarefaction analyses were used to compare species richness within each category of diet, forest dependence and forest strata whenever a greater richness in a given habitat was also associated with greater abundance. For rarefaction analyses we report the average richness and 95% confidence intervals (CI) derived from 1000 iterations. Total refers to the whole community

	Bamboo		Non-bamboo		Rarefaction	
	Richness	Abundance	Richness	Abundance	Average richness	95% CI
Diet						
Frugivores	18	136	15	167		
Insectivores	41	244	32	203	39.3	37–41
Granivores	11	79	7	111		
Nectarivores	4	75	1	55		
Forest dependence						
Dependent	58	505	51	520		
Semi-dependent	12	24	4	16	9.6	8–11
Independent	4	5	0	0		
Forest strata						
Canopy	13	81	14	99	11.7	9–14
Mid+ Understorey	45	424	37	421	44.9	44–45
Total	74	534	55	536		

Table 2. Estimators of species richness (Chao 2, Jackknife 1, Jackknife 2, Bootstrap; see Methods) for bamboo and non-bamboo habitats

	Number of species	Chao (s.e.)	Jack1 (s.e.)	Jack 2	Bootstrap (s.e.)
Bamboo	74	98.14 (12.47)	98 (8.59)	109.14	85.06 (4.68)
Non-bamboo	55	75.64 (13.48)	70.7 (6.35)	79.65	62.03 (3.39)

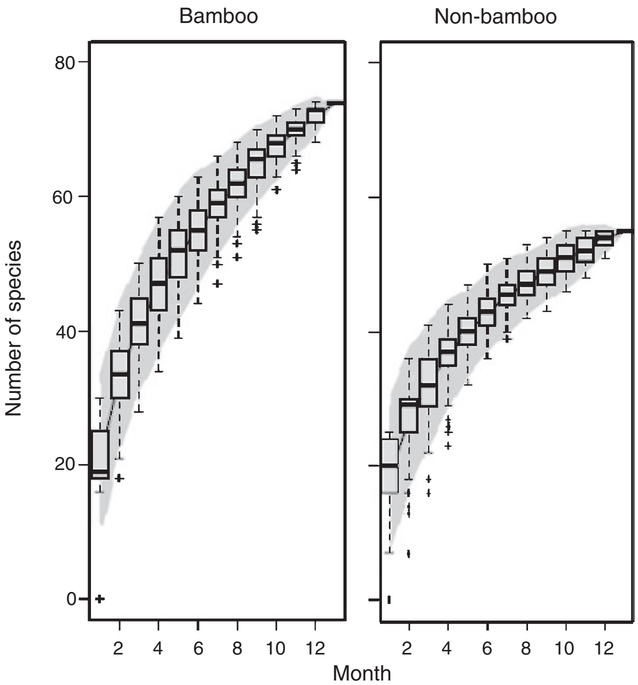

Fig. 1. Cumulative curve (rarefaction) of the number of bird species recorded in bamboo and non-bamboo habitats over the duration of the study. The grey envelope represents the 95% confidence interval for 1000 permutations. Box plots represent the median (dark bar), 25th and 75th percentiles, and outlier values for the estimated number of species for each month. The months sampled were from May 2008 to April 2009 (except October 2008).

Bamboo and non-bamboo habitats had a similar number of canopy species, but differed in the number of non-canopy (i.e. midstorey plus understorey) species, with greater species richness in bamboo habitats than non-bamboo habitats (Table 1).

The abundance of the whole avian community, and of each of the dietary categories separately, varied over time but not differ between bamboo and non-bamboo habitats. There was no significant interaction between temporal and habitat factors (Table 3). Only two of 15 species (White-eyed Foliage-gleaner (*Automolus leucophthalmus*) and White-collared Foliage-gleaner (*Anabazenops fuscus*)) normally associated with bamboo habitats had higher number of records in non-bamboo habitat than bamboo habitat, but the abundance of most of them was low (<5 records; Appendix 1). If we exclude the Ferruginous Antbird (*Drymophila ferruginea*), which is a bamboo specialist, from analysis of bamboo habitats, the five most common species were the same for both bamboo and non-bamboo habitats (Fig. 2).

The overall species composition differed between bamboo and non-bamboo habitats ($R = 0.24$, $P = 0.03$), with composition more spatially homogeneous in non-bamboo habitats (Fig. 3). The species composition of frugivores also differed between habitats ($R = 0.38$, $P = 0.05$) but species composition of insectivores ($R = -0.12$, $P = 0.76$) and granivores ($R = 0.01$, $P = 0.44$) did not differ between habitats. Although some frugivorous species occurred more frequently in bamboo habitats (e.g. Swallow-tailed Manakin (*Chiroxiphia caudata*)), others were recorded more frequently in non-bamboo habitats (e.g. Bare-throated Bellbird (*Procnias nudicollis*), White-necked Thrush (*Turdus albicollis*); Appendix 1).

Discussion

More species of bird were found in bamboo habitats than non-bamboo habitats, although the abundance of each species was similar in each habitat, and many species that are not bamboo specialists use bamboo habitats. These results appear to be robust and not an artefact of different detection probabilities within bamboo and non-bamboo habitats. Some evidences support this conclusion. Firstly, the differences in tree density (see Methods) of the vegetation between bamboo and non-bamboo habitats were not great, which is further supported by the number of canopy bird species in each, which did not differ between bamboo and non-bamboo habitats despite the more open canopy of bamboo habitats that, in turn, might lead to an increased probability of detecting canopy birds. Secondly, the greater richness of bird species in the understorey of bamboo habitats does not correspond with the phenomenon of lower detection probability owing to the much denser understorey in bamboo habitats.

Two features of bamboo patches cause them to be used frequently by birds irrespective of any putative specialisation of birds on bamboo habitats. Firstly, patches of bamboo are immersed in a matrix of mature forest, forming a mosaic of areas with and without bamboos. Because individual patches of bam-

Table 3. Results of the repeated-measure ANOVA of the abundance of birds at each month from April 2008 to April 2009 (except October 2008; transformed data log + 1) in bamboo and non-bamboo habitats

Total is the whole avian community (all dietary classes). MS, mean square

Effects	Degrees of freedom	Total			Frugivores			Insectivores			Granivores		
		MS	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*
Habitat	1	0.0007	0.006	0.94	0.1302	1.69	0.23	0.0516	0.29	0.60	0.3028	5.06	0.06
Error	8	0.1220			0.0768			0.1767			0.0598		
Month	11	0.2752	5.41	<0.001	0.4496	7.39	<0.001	0.1175	2.13	0.03	0.2059	4.08	<0.001
Month × Habitat	11	0.0221	0.43	0.94	0.0351	0.58	0.84	0.0466	0.84	0.60	0.0555	1.10	0.37
Error	88	0.0509			0.0609			0.0552			0.0504		

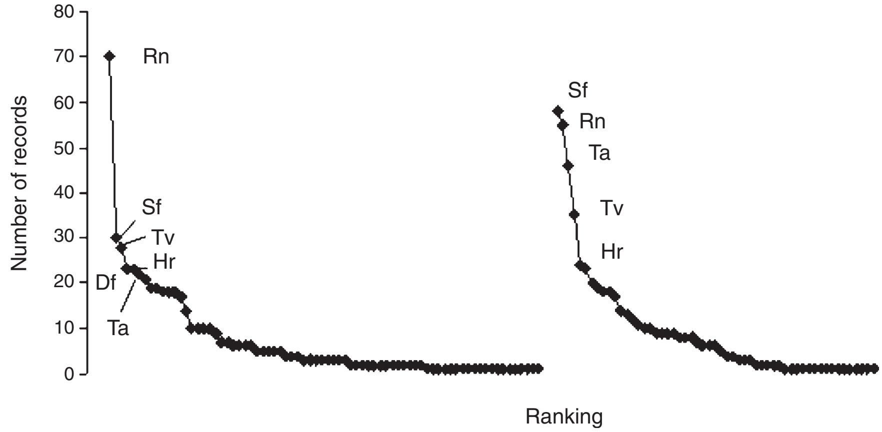

Fig. 2. Species abundance curves for birds recorded in bamboo and non-bamboo habitats. On the horizontal axis, species are ranked from the most abundant to the least abundant. Codes for the most abundant species: Rn, Saw-billed Hermit (*Ramphodon naevius*); Sf, Black-throated Grosbeak (*Saltator fuliginosus*); Tv, Green-backed Trogon (*Trogon viridis*); Hr, Red-crowned Ant-Tanager (*Habia rubica*); Df, Ferruginous Antbird (*Drymophila ferruginea*); Ta, White-necked Thrush (*Turdus albicollis*).

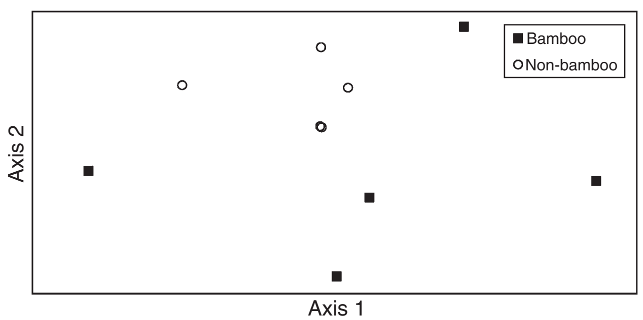

Fig. 3. Non-metric multi-dimensional scaling based on the presence–absence of bird species at the five sampling points in bamboo (squares) and non-bamboo (circles) habitats. The closer points are the more similar the species composition (based on Morisita similarity index).

boos are not large, they can be readily traversed and used by birds moving between non-bamboo habitats. Secondly, many plant species other than bamboos manage to persist or grow within bamboo patches, possibly providing sources of food or simply perches or shelter.

Nevertheless, patches of bamboo were reasonably distinct from the surrounding forest in avian composition, especially in occurrence of bamboo specialists and birds not dependent on forested habitats. In addition, the species composition of bamboo habitats were less homogeneous than non-bamboo habitats, which is likely to reflect the patchy occurrence of these bamboo specialists and birds not dependent on forested habitats, which, overall, were recorded at low density and in only some patches. The structural similarity between bamboo habitats and early successional habitats has been already noticed (Kratter 1997) and may favour the occurrence of birds not restricted to mature forests, like many of the species classified here as semi-dependent or independent of forests. These birds may use bamboo habitats as a source of resources or as stepping stones during their movements through an otherwise continuous mature forest. In addition, patches of bamboo may offer protection against predators, as hypothesised for birds in the Chilean temperate forests (Reid *et al*. 2004).

Not surprisingly, insectivores were the most common and abundant birds in both bamboo and non-bamboo habitats. In bamboo habitats, part of the insectivore guild is formed by species typically associated with bamboos, which, however, were not restricted to bamboo habitats. Some bamboo specialists (e.g. the White-collared Foliage-gleaner) were frequently recorded in non-bamboo habitats, which they may traverse while moving between patches of bamboo or use occasionally for foraging (Rodrigues *et al*. 1994). With the exception of the Ferruginous Antbird, none of the bamboo specialists are among the most abundant species. Therefore, although present, most of the insectivorous bamboo specialists occurred in low densities in bamboo habitats.

Confirming our expectations, frugivores seem to be the dietary category least common in bamboo habitats. However, frugivores did not completely avoid bamboo habitats, and some species seem to be more prone to use bamboo patches than others, resulting in the different composition of frugivores between habitats. The use of bamboo habitats by frugivores might be a result of their sensitivity to forest disturbances (Stotz *et al*. 1996). For instance, Swallow-tailed Manakin, the frugivore most often recorded in bamboo habitats (Appendix 1), is a forest-dependent species with a low sensitivity to disturbance (Stotz *et al*. 1996). Because different bird species eat different species of fruit, the difference in frugivore composition may have consequences for the input of seeds into bamboo habitats, which is likely to contribute to the difference in the composition of the seed rain between bamboo and non-bamboo habitats already noted at the study site (Rother *et al*. 2009).

Despite the presence of some granivores typically associated with bamboos (e.g. Uniform Finch (*Haplospiza unicolor*), Buffy-fronted Seedeater (*Sporophila frontalis*)), granivores were not especially abundant in this study, although they can be abundant when bamboo is fruiting (Olmos 1996). Our study did not coincide with a fruiting episode of *G. tagoara*. Of the nectarivorous species, it is noteworthy that one of the most abundant species in both bamboo and non-bamboo habitats was the hummingbird (Saw-billed Hermit, *Ramphodon naevius*), which is a trapliner that regularly flies over feeding routes to visit flowers (Sazima *et al*. 1995). Although it did not visit flowers inside bamboo patches, its routes might traverse them, leading to its repeated recording in bamboo patches.

In conclusion, we have shown that bamboo habitats, although avoided by some species, provide habitat for avian bamboo specialists and many non-specialist birds. At a local scale, bamboos enhance the structural heterogeneity of forest, thus promoting bird diversity. Our results parallel those of Díaz *et al*. (2005), who found that patches of bamboo within Chilean temperate rainforests are among the critical structural elements contributing to the abundance and species richness of birds inhabiting old-growth forests. The expansion of *G. tagoara* as discrete patches immersed in pristine forests may be considered as an example of the intermediate disturbance hypothesis, which predicts local species diversity to be maximal at an intermediate level of disturbance (Connell 1978). At the study site, *G. tagoara* still does not dominate large areas, and the forest structure was altered but not greatly disrupted by the presence of bamboos. The canopy formed by non-bamboo species within bamboo habitats was discontinuous but preserved, whereas the understorey had many bamboo culms as well as other plant species. Therefore, at the level of occurrence of bamboos we sampled, *G. tagoara* is not detrimental to the avian community. On the contrary, an extensive network of discrete bamboo patches seems critical to the survival of bamboo specialists, many of them threatened with extinction in the Atlantic forest (e.g. White-bearded Antshrike (*Biatas nigropectus*), Buffy-fronted Seedeater, Temminck's Seedeater (*Sporophila falcirostris*), Purple-winged Ground Dove (*Claravis godefrida*); Areta *et al*. 2009). The progression of bamboo expansion and eventual fusion of bamboo patches may lead to the situation presently found in the south-western Amazon where bamboos form extensive monocultures (Griscom and Ashton 2003). It thus remains to be seen what will be the response of the avian community to the ongoing expansion of the bamboo *G. tagoara* in the Atlantic forest.

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Appendix 1. The abundance (number of records) of all species of birds in bamboo and non-bamboo habitats, indicating diet (I, insectivore; F, frugivore; G, granivore; N, nectarivore), forest dependence (D, forest dependent; S, semi-dependent; I, independent) and forest strata (C, canopy; M, mid-storey; U, understorey); see paper for fuller definitions of categories

Only species dependent on forests were classified for forest strata

Family and species	Common names	Diet	Forest dependence	Forest strata	Abundance Bamboo	Abundance Non-bamboo
TINAMIDAE						
Crypturellus obsoletus	Brown Tinamou	G	D	U	3	6
Tinamus solitarius	Solitary Tinamou	G	D	U	18	23
CRACIDAE						
Penelope obscura	Dusky-legged Guan	F	D	M	1	0
Pipile jacutinga	Black-fronted Piping-Guan	F	D	M	1	1
ODONTOPHORIDAE						
Odontophorus capueira	Spot-winged Wood-Quail	G	D	U	5	6
COLUMBIDAE						
Patagioenas plumbea	Plumbeous Pigeon	G	D	C	9	14
PSITTACIDAE						
Brotogeris tirica	Plain Parakeet	G	D	C	7	3
Pyrrhura frontalis	Maroon-bellied Parakeet	G	D	C	0	1
Forpus xanthopterygius	Blue-winged Parrotlet	G	I		1	0
Pionus maximiliani	Scaly-headed Parrot	G	S		1	0
CUCULIDAE						
Piaya cayana	Squirrel Cuckoo	I	S		3	4
TROCHILIDAE						
Amazilia fimbriata	Glittering-throated Emerald	N	S		1	0
Phaethornis squalidus	Dusky-throated Hermit	N	D	U	3	0
Ramphodon naevius	Saw-billed Hermit	N	D	U	70	55
TROGONIDAE						
Trogon viridis	Green-backed Trogon	F	D	M	28	35
RAMPHASTIDAE						
Ramphastos dicolorus	Red-breasted Toucan	F	D	C	1	1
Selenidera maculirostris	Spot-billed Toucanet	F	D	M	6	3
PICIDAE						
Celeus flavescens	Blond-crested Woodpecker	I	D	M	2	1
Dryocopus lineatus	Lineated Woodpecker	I	S		1	0
Picumnus sp.		I	D	M	2	2
FURNARIIDAE						
Anabazenops fuscus[A]	White-collared Foliage-gleaner	I	D	U	3	9
Automolus leucophthalmus[A]	White-eyed Foliage-gleaner	I	D	U	10	13
Heliobletus contaminatus	Sharp-billed Treehunter	I	D	M	1	0
Philydor atricapillus	Black-capped Foliage-gleaner	I	D	U	10	8
Sclerurus scansor	Rufous-breasted Leaftosser	I	D	U	2	4
Synallaxis ruficapilla[A]	Rufous-capped Spinetail	I	D	U	3	0
Synallaxis spixi	Spix's Spinetail	I	I		2	0
FURNARIIDAE (all DENDROCOLAPTINAE)						
Campylorhamphus trochilirostris[A]	Red-billed Scythebill	I	D	M	0	1
Dendrocincla turdina		I	D	M	0	1
Dendrocolaptes platyrostris	Planalto Woodcreeper	I	D	M	2	2
Sittasomus griseicapillus	Olivaceous Woodcreeper	I	D	C	2	0
Xiphocolaptes albicollis	White-throated Woodcreeper	I	D	M	0	1
COTINGIDAE						
Lipaugus lanioides	Cinnamon-vented Piha	F	D	M	14	10
Procnias nudicollis	Bare-throated Bellbird	F	D	C	5	19
PIPRIDAE						
Chiroxiphia caudata	Swallow-tailed Manakin	F	D	U	21	9
TITYRIDAE						
Schiffornis virescens	Greenish Schiffornis	I	D	U	0	2

(*Continued next page*)

Appendix 1. (*continued*)

Family and species	Common names	Diet	Forest dependence	Forest strata	Abundance Bamboo	Abundance Non-bamboo
TYRANNIDAE						
Attila rufus	Gray-hooded Attila	I	D	M	4	2
Elaenia flavogaster	Yellow-bellied Elaenia	F	S		1	0
Hemitriccus diops[A]	Drab-breasted Pygmy-Tyrant	I	D	M	3	0
Lathrotriccus euleri	Euler's Flycatcher	I	D	U	3	0
Megarynchus pitangua	Boat-billed Flycatcher	I	S		1	0
Myiodynastes maculatus	Streaked Flycatcher	I	S		2	1
Pachyramphus polychopterus	White-winged Becard	I	D	C	0	1
Tolmomyias sulphurescens	Yellow-olive Flycatcher	I	D	C	10	9
THAMNOPHILIDAE						
Batara cinerea[A]	Giant Antshrike	I	D	U	6	3
Drymophila ferruginea[A]	Ferruginous Antbird	I	D	M	23	12
Drymophila ochropyga[A]	Ochre-rumped Antbird	I	D	U	6	1
Drymophila genei[A]	Rufous-tailed Antbird	I	D	U	1	0
Drymophila malura	Dusky-tailed Antbird	I	D	U	2	1
Dysithamnus mentalis	Plain Antvireo	I	D	M	19	18
Dysithamnus stictothorax	Spot-breasted Antvireo	I	D	M	18	11
Hypoedaleus guttatus	Spot-backed Antshrike	I	D	C	2	1
Mackenziaena severa[A]	Tufted Antshrike	I	D	U	5	1
Myrmeciza loricata	White-bibbed Antbird	I	D	U	5	8
Pyriglena leucoptera[A]	White-shouldered Fire-eye	I	D	U	7	0
FORMICARIIDAE						
Chamaeza meruloides	Such's Antthrush	I	D	U	17	18
GRALLARIIDAE						
Grallaria varia	Variegated Antpitta	I	D	U	1	8
Hylopezus nattereri[A]	Speckle-breasted Antpitta	I	D	U	1	0
RHINOCRYPTIDAE						
Merulaxis ater	Slaty Bristlefront	I	D	U	10	9
Scytalopus speluncae[A]	Mouse-colored Tapaculo	I	D	U	2	0
VIREONIDAE						
Cyclarhis gujanensis	Rufous-browed Peppershrike	I	S		6	5
TURDIDAE						
Turdus flavipes	Yellow-legged Thrush	F	D	C	4	10
Turdus albicollis	White-necked Thrush	F	D	M	22	46
Turdus rufiventris	Rufous-bellied Thrush	F	S		3	6
COEREBIDAE						
Coereba flaveola	Bananaquit	N	I		1	0
THRAUPIDAE						
Saltator fuliginosus	Black-throated Grosbeak	G	D	M	30	58
Tangara cyanocephala	Red-necked Tanager	F	D	C	0	1
Tangara seledon	Green-headed Tanager	F	D	C	2	1
Thraupis cyanoptera	Azure-shouldered Tanager	F	D	C	1	1
Tachyphonus coronatus	Ruby-crowned Tanager	F	D	M	5	7
Thraupis palmarum	Palm Tanager	F	I		1	0
Habia rubica	Red-crowned Ant-Tanager	I	D	U	23	24
EMBERIZIDAE						
Arremon flavirostris	Saffron-billed Sparrow	G	D	U	1	0
Haplospiza unicolor[A]	Uniform Finch	G	S		2	0
Sporophila frontalis[A]	Buffy-fronted Seedeater	G	S		2	0
PARULIDAE						
Basileuterus culicivorus	Golden-crowned Warbler	I	D	M	4	2
Basileuterus leucoblepharus	White-browed Warbler	I	D	U	1	0
Basileuterus leucophrys	White-striped Warbler	I	S		1	0
ICTERIDAE						
Cacicus haemorrhous	Red-rumped Cacique	I	D	C	18	20

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Appendix 1. (*continued*)

Family and species	Common names	Diet	Forest dependence	Forest strata	Abundance	
					Bamboo	Non-bamboo
FRINGILLIDAE						
Euphonia pectoralis	Chestnut-bellied Euphonia	F	D	C	19	17
Euphonia violacea	Violaceous Euphonia	F	D	C	1	0

[A]Species typically associated with bamboos.