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CHANGES IN UNDERSTORY AVIFAUNA ALONG THE SINNAMARY RIVER (FRENCH GUYANA, SOUTH AMERICA)

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Résumé. Le bassin de la rivière Sinnamary comporte une succession d'habitats, de la forêt primaire à la forêt sur cordons sableux de la plaine côtière récente. En prenant comme référence une détermination de l'avifaune de sous-bois en forêt primaire non dépendante d'un bassin versant (P), nous avons déterminé qualitativement et quantitativement par la méthode des captures-baguages la population d'oiseaux sur quatre habitats différents: 1) une forêt haute de terre ferme sur bassin versant (B); 2) un gradient de recrus forestiers de cinq à vingt ans (forêt secondaire) (S); 3) une forêt ripicole inondable pluristratifiée (R); et 4) une forêt sur cordon sableux ancien proche de l'embouchure (E). L'activité journalière, la densité, la biomasse aviaire sont analysées dans ces formations végétales. La composition de l'avifaune est comparée dans les différents habitats en utilisant comme unité de densité relative le nombre d'individus capturés pour 100 heures par 100 m filet de mailles de 19 mm. Les populations d'oiseaux sont caractérisées: 1) en forêt primaire par une présence importante d'insectivores, surtout des spécialistes capturant leurs proies sur la végétation (gleaners, IF) et des petits frugivores mangeurs de baies, l'espèce la plus importante étant le fourmilier *Pithys albifrons*; 2) en forêt secondaire existe la plus vaste gamme de guildes et d'espèces; 42 d'entre elles se retrouvent dans au moins deux autres milieux; et 3) en forêt ripicole il y a très peu de granivores et de nectarivores aux strates inférieures. Les pics et les grimpars comme *Glyphorynchus spirurus* , les Pipridae *Pipra aureola* et *Manacus manacus*, sont les espèces représentatives de cet habitat. La forêt sur cordon sableux ancien présente une avifaune très différente. Seules dix espèces sont communes avec au moins deux autres habitats mais aucune des cinq espèces dominantes ne sont présentes; 20 espèces sont spécifiques. Nectarivores et granivores forment les constituants caractéristiques de cette population relativement riche aussi en espèces capturant au vol des insectes (sallying, IA). *Amazilia leucogaster*, *Galbula galbula*, sont parmi les espèces les plus caractéristiques de cet habitat. La forêt primaire de la vallée de la Sinnamary est d'une grande diversité, semblable aux données de référence de captures dans d'autres forêts primaires de Guyane.

Abstract. Along the Sinnamary basin in French Guyana (South America) a succession of forest types occurs from the Ridge forest at the mouth of the river to the primary rain forest on the slopes of the narrowing valley 100 km to the south but only 35 m above sea level at the upper part of the dam reservoir of Petit-Saut. The aim of the present work was to determine the relationship between bird community structure and river zonation. This study will point out the variations in species richness and trophic structure for understory avifaunas in four forest habitats of the Sinnamary basin : 1) Sinnamary river mature rain forest: slopes of the valley at less than 100 m from the Sinnamary river and at 100 km of the mouth ; 2) Secondary forest (25 km from the mouth): from clear cuts at various stages of growth; 3) Riparian forest on wet, seasonally flooded bottom flats; 4) Ridge forest: close to the mouth of the river on sand Ridges. Understory avifaunas for these habitats are compared each other as well as with those of mature primary rain forest habitats found outside the Sinnamary basin. Cumulative curves, daily activities and biomasses are not significantly different between habitats. However, the principal component analysis shows marked differ-

ences in understory bird community composition between these habitats. The habitats are ranked in order of their distance from the sea along the Sinnamary River. The Sinnamary river mature rain forest understory bird composition is similar to that of the reference primary forest. The highest diversity for gleaning insectivore and frugivorous species was found in the Sinnamary mature rain forest. The Secondary forest had the highest number of species captures. The Riparian forest was characterised by a relatively high number of gleaning insectivores and a lack of terrestrial insectivores, granivores and nectarivores. The Ridge forest was markedly different from the other habitats; only ten species found in this habitat were present in at least two of the other forest types, 20 species were unique to this habitat, mainly Picidae and nectarivores. *Accepted 20 March 1997*.

Key words: Understory avifauna, guilds, tropical forest, French Guyana, South America.

INTRODUCTION

Each habitat possesses a characteristic bird population composed of specialists, generalists and accidental species. Along a river, biological approaches to river continuum stem from the observations that there exists an upstream-downstream succession of species, which can be divided into zones. Structuring of bird communities in relation to fluvial systems and the architecture of alluvial landscapes has been studied in Europe (Roché & Frochot 1993). In tropical America, information on the structure of neotropical bird communities is scarce and refers mainly to mature tropical forests based on the alpha diversity of small areas of relatively homogeneous habitats (Lovejoy 1974, Karr *et al.* 1982, Whittaker 1977).

The beta diversity in forest bird assemblages compares how similar communities are structured between two tracts of different types of forests (Monkkonen 1994). Along the Sinnamary basin, in French Guyana (South America), a succession of forest types occurrs from Ridge forest at the mouth of the river (de Granville 1986) to primary rain forest on the slopes of the narrowing river valley 100 km to the south but only 35 m above sea level, at the upper part of the dam reservoir of Petit-Saut.

During the impact study for the Petit-Saut dam in the central rain forest of French Guyana, in an area of less than 5 km^2, 282 species were observed (Anonymous 1988) compared to the total of around 710 species assumed to be in the entire country. In an area of 50 km^2 around the Petit-Saut damp 320 to 350 species are present. The species diversity is very high, but reliable quantitative information on the structure and composition of the bird community is difficult to obtain. The reasons are that most of the species are heard and not seen, and identification by their call requires considerable practice (Terborgh *et al.* 1990). Also, given the lack of quantitative information, the spot-mapping technique (Blondel *et al.* 1970) that is standard temperate zone census-methodology is seldom applied.

The understory strata in lowland habitats (< 50 m) of French Guyana have a high number of species, around 23% of total species composition (Thiollay 1987). Terborgh (1985) estimated that the mist net technique (capture-recapture), when used to quantify bird community structure provides a severely biased estimate, as no more than 40% of the species present in a tall forest may be captured. Despite these sampling difficulties, the use of a standardised methodology (the mist net technique) provides the best method of simultaneous sampling from different habitats (Poulin *et al.* 1993). Mist-netting censuses are essential for research on tropical bird communities (Schemske & Brokaw 1991).

TABLE 1. Sites and netting dates for each habitat. See text for definitions.

Habitat	Site	Netting dates	Number of net-hours
Primary forest: 5 sites	P1	April-May 1990	300
	P2	May 1991	157
	P3	May 1991	229
	P4	April 1991	214
	P5	April 1991	203
Sinnamary forest: 3 sites	B1	December 1993	193
	B2a	December 1993	215
	B2b	June 1994	188
	B2c	October 1994	236
	B3a	December 1993	240
	B3b	June 1994	266
	B3c	October 1994	247
Secondary forest: 3 sites	S1	December 1991	248
	S2	December 1991	216
	S3a	April 1994	238
	S3b	August 1994	266
	S3c	January 1995	210
	S3d	May 1995	238
	S3e	July 1995	255
Riparian forest: 3 sites	R1	June 1994	255
	R2	July 1992	258
	R3a	February 1995	264
	R3b	April 1995	72
	R3c	August 1995	60
Ridge forest: 2 sites	E1	June 1994	50
	E2a	December 1994	200
	E2b	January 1995	68
	E2c	February 1995	60
	E2d	August 1995	72

The aim of the present work is to determine, with such a gradient of forest habitat along the Sinnamary river, the convergences and the divergences among bird communities. This study will point out the variations in species richness and trophic structure for understory avifaunas in four forest habitats of the Sinnamary basin in relation to the

TABLE 2. Understory avifauna predominant feeding guild composition in the five habitats: total and relative number of species. FA: arboreal frugivore; GR: granivore; IA: sallying insectivore; IB: bark-dwelling insectivore; IF: arboreal, gleaning insectivore; IT: terrestrial insectivore; NI: nectarivore; OA: omnivore.

Guild	Primary f.	Sinnamary f.	Secondary f.	Riparian f.	Ridge f.	Total
FA	7	6	7	4	2	8
%	12	9	9	10.2	4	5.1
GR	1	1	4	1	3	7
%	1.7	1.5	5	2.6	6.1	4.5
IA	10	11	11	5	10	30
%	17	16.5	15	12.8	20.4	19.2
IB	3	6	3	5	9	12
%	5	9	4	12.8	12.2	7.7
IF	19	19	24	14	14	43
%	32	28	32	35.8	28.6	27.5
IT	11	8	5	2	2	18
%	18.6	12	11	5	4	11.5
NI	5	7	11	3	7	18
%	8.5	10.5	15	7.7	14.3	11.5
OA	3	9	10	4	4	18
%	5	13.5	13	10.3	8	11.5
TOTAL	59	67	75	39	49	156

understory avifaunas of rain forests beyond the Sinnamary basin.

MATERIAL AND METHODS

Netting sessions

We investigated understory bird populations in different habitats along the Sinnamary river with the use of mist nets between 1990 and 1995 (Table 1). Sampling dates were chosen mainly during the rainy seasons: October to February and April to August. Due to the difficulties of access, to the cost of each expedition to most of the sites, and to the poor capture rate after a two-days session, the number of sites is 16 for 29 sessions. At each site, mist-nets (2.2 x 12 m, 19 mm mesh) were operated for a 10-h period beginning at dawn, two days in a row (20 h per line). The nets were set tightly between poles to capture birds flying between 10 cm and 2.20 m above ground level. Nets were checked every 1–2 h, and closed temporarily during periods of heavy rain. Birds were weighed and marked to permit identification of later re-captures. Hour of capture was noted for use in assessing diurnal activity pattern.

Habitat classification

Each site was identified to habitat based on the marked differences in vegetation characteristics according to the descriptions of

TABLE 3. The five dominant species of each habitat ranked from 1 to 5 in decreasing order of mean frequency of occurrence per plot (and percentage of total captures). FA: arboreal frugivore; IA sallying insectivore; IB: bark-dwelling insectivore; IF: arboreal, gleaning insectivore; IT: terrestrial insectivore; FH: fish-eating bird; NI: nectarivore; OA: omnivore.

Species	Guild	Primary f.	Sinnamary f.	Secondary f.	Riparian f.	Ridge f.
Pipra serena	FA	3 (5.5)	3 (7.2)	3 (5.9)		
Pipra pipra	FA	1 (12)	2 (13.4)	1 (9.2)		
Pipra aureola	FA				3 (8.2)	2 (11.6)
Manacus manacus	FA			6 (4.3)	4 (6.8)	
Glyphorynchus spirurus	IB	6 (3.1)	4 (6.2)	8 (3.7)	1 (11.0)	
Conirostrum bicolor	IF					5 (4.6)
Phaeomyias murina	IA					3 (9.3)
Pithys albifrons	IT	2 (5.8)	1 (18.5)	2 (6.9)		
Gymnopithys rufigula	IT	7 (3.1)	5 (5.1)			
Hylophilax poecilonota	IT	5 (4.1)	7 (2.0)			
Formicivora grisea	IT					4 (4.7)
Chloroceryle aena	FH				2 (8.9)	
Thalurania furcata	NI	4 (5.5)	10 (1.3)			
Glaucis hirsuta	NI			5 (5.3)		
Amazilia leucogaster	NI					1 (20.0)
Mionectes oleaginea	OA		8 (2.3)	10 (2.1)	5 (4.8)	
Ramphocelus carbo	OA			4 (5.3)	6 (4.1)	6 (3.8)

Lindeman (1953) and de Granville (1986, 1993). Four habitats found along the Sinnamary River are being compared with each other and with a fith habitat : mature primary rain forest outside the Sinnamary Basin. The rainfall is 2000–4000 mm.

Mature Primary Rain forest. Mature stands with a canopy exceeding 40m in height and emergent trees reaching 60m; open understory and closed canopy on well-drained slopes and plateaux, including treefall gaps at various stages of regeneration. Most of the flowering occurs in September-October, and most of the fructification occurs in February-March (Sabatier & Puig 1986). One site was located in the Nouragues Nature Reserve (P1), while the other four were located along the future road between Regina and Saint Georges; the closed large water courses are more than 20 km far away. To differentiate this habitats from the others one we will use the expression "Primary forest" in the text.

Sinnamary River Basin forest. 1) Sinnamary River valley Mature Primary Rain forest: located less than 100 m from the Sinnamary river in two locations: Saut Dalle (B1) and Saut Aimara (B2, B3) at more than 75 km from the mouth on the upper part of the river. The forest is composed of tall, mature stands with open understory and closed can-

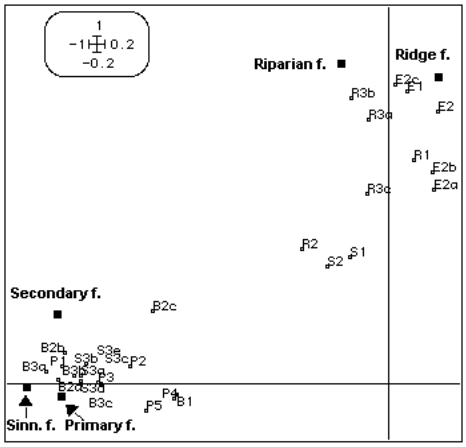

FIG. 1. Ordination of habitats and sites by the principal component analysis for the understory birds captures. P: Primary forest; B: Sinnamary forest; S: Secondary forest; R: Riparian forest; E: Ridge forest. See Table 1 for details.

opy on well drained slopes and plateaux; no treefall gaps were noticed. To differentiate this habitats from the others one we will use the expression "Sinnamary forest" in the text. 2) Secondary forest (25 km from the mouth): clear cuts at various stages of growth from dense bush 2–4 m high entangled with almost impenetrable vine (S1), to 10–12 m small trees with dense undergrowth (S2). Site S3 is an 18 year old regrowth stage after a total deforestation. Its dominant vegetation is *Casearia rusbyana*, *Vismia latifolia*, *Miconia fragilis*, *Sapium paucinervium*; most of the fructification occurred between March and September (D. Toriola, pers. comm.). Five netting sessions were done between April 1994 and July 1995. 3) Riparian forest on wet, seasonally flooded bottom flats along watercourses (three sites at 3, 5 and 10 km from the mouth). The canopy is 20–30 m high; the low undergrowth is made of Cyperaceae and Melastomaceae. These strips of forest are 100m to 500m wide, bordered by clearings covered with Malpighiaceae. 4) Ridge forest: close to the mouth of the river, growing on white sand soil, low bushes, 2–4 m high of *Hibiscus tiliaceus* (Malvaceae), bordered with Cactacae (*Cereus hexagonus*), and large trees 15–25 m high (*Hymenaea courbaril*, *Protium heptaphyllum*, *Tapirira guianensis* and *Spondias monbin*); the understory is mainly covered with an Arecacea (*Astrocaryum vulgare*).

Data analysis

Data analyses were performed with the ADE program 3.7 (Chessel & Doledec 1994). To establish the relationships between habitats, a principal component analysis was done with all the species (Maurer *et al.* 1981). Species were weighted with regard to their relative density. To show the relationships between species and habitats, a correspondence analysis (Rottenberry & Wiens 1981) was done on the 47 most common species (those comprising at least 1.5% of the individuals in a given habitat).

RESULTS

Species richness and abundance. For all five habitats a total of 1336 birds representing 155 species in 30 families was captured. A list of all species captured with the number of captures in each habitat is given in the Appendix. The highest capture numbers are for *Pithys albifrons* (110 birds) and *Pipra pipra* (115). Capture rate is about the same in primary forests: 0.26 and 0.25 captures per net-h. Capture rate decreases markedly in Secondary forest (0.18) and in Riparian forest (0.16), but is higher in the Ridge forest (0.48 captures/net-h).

Daily activity. Capture times may be influenced by foraging behavior (Delauriers & Francis 1990), therefore an activity index was calculated for each habitat based on number of birds captured per hour during the first day of each mist net session. The main activity in all habitats occurred from 06:00–10:00 h: 57%

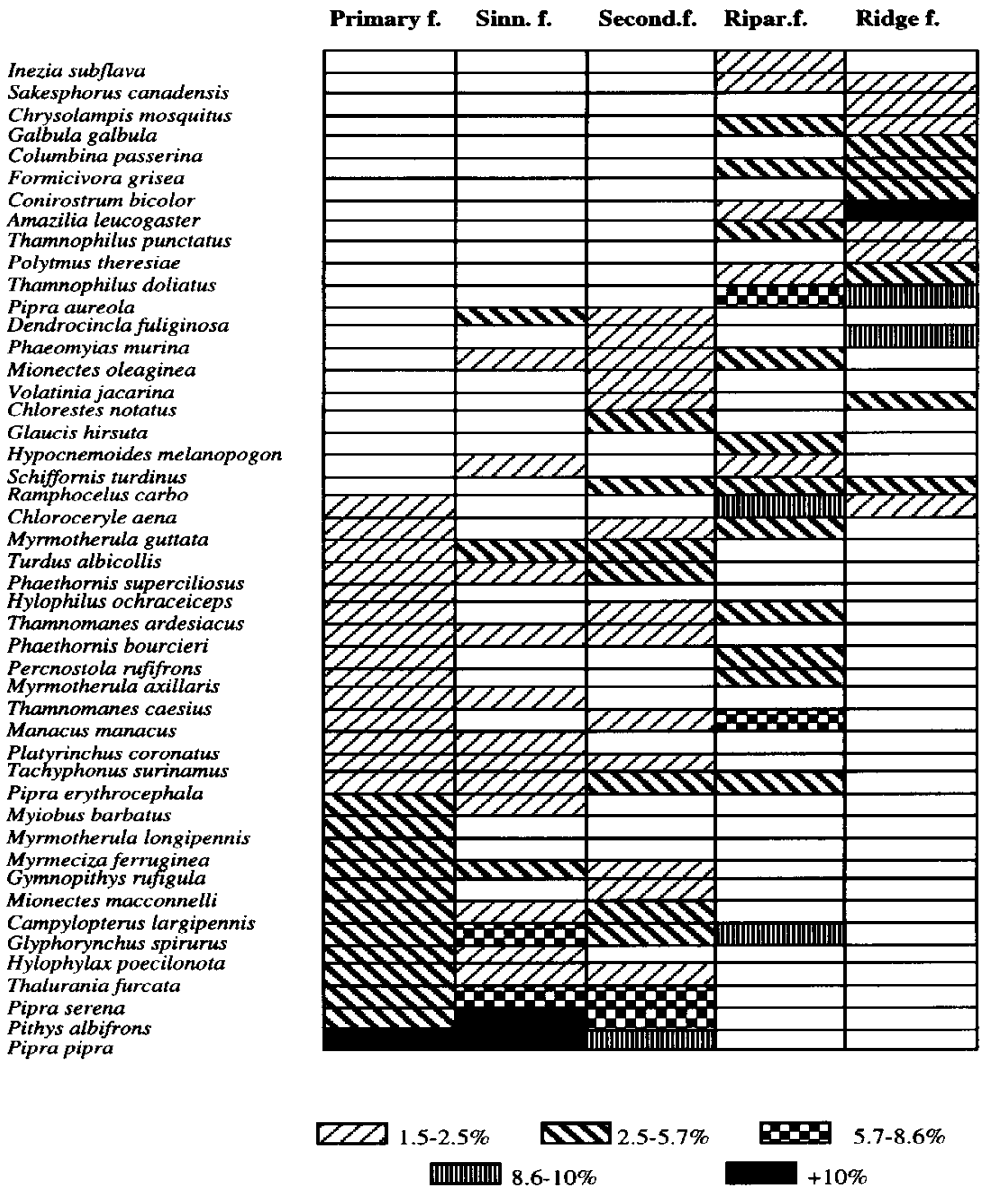

FIG. 2. Correspondance analysis on the relative density for the 47 most common species in the five habitats.

of the birds were captured during this period. After 10:00 h, the activity decreased continually in the Secondary forest and in the Riparian forest where the canopy was sparse or very low. For the other habitats, after a marked decrease around noon (only 10% of

the birds were captured between 11:00–13:00 h), the activity increased during the afternoon. From 16:00 h to dark, 14% of the birds were captured

The relative size of each guild is the same for morning or evening. Some species were noticeably more abundant during the evening: *Mionectes maconelli* (45%) and *M. oleaginea* (30%), *Platyrynchus saturatus* (30%), *Myrmotherula longipennis* (33%) and *M. axillaris* (31%). The evening activity of these arboreal, gleaning insectivores seems parallel with the evening emergence of nocturnal insects.

Biomass distribution. The total bird biomass (Appendix) and the mean individual mass (minimum 15.7 g for Primary forest, maximum 20.5 g in Sinnamary forest) did not differ significantly. Based on the mist-netting censuses (g per net-h), the biomass shows a large difference between the Ridge forest (8.1) and the four other habitats (3.2 to 5).

Global changes. Figure 1 shows the principal component analysis for all the species for the 29 sampling sessions and for the means in each habitat on axis 1 and 2. To reduce bias associated with species size, raptors are excluded from the analysis. The habitats are diagonalised between axes 1 and 2. They are ranked in order according to their position along the Sinnamary river. Axis 1(inertia: 35%) separated Ridge (E) and Riparian (R) forest habitats from Primary and Secondary forests; Axis 2 (inertia: 14%) separated first Primary (P) and Sinnamary (B) forests and also Ridge (E) and Riparian (R). The Primary forest bird population is similar to that of the Sinnamary forest. Riparian and Ridge forests have some similarities; the Secondary forest bird population is between the two groups, but well separated.

Feeding guild composition. Table 2 shows the guild composition for each habitat. The distribution of species and individuals among guilds differs for each forest. The main guild in all habitats is the arboreal gleaning insectivores (27 to 36% of the species captured).

Primary, Sinnamary and Riparian forests are similar in their composition of frugivores, mainly Pipridae, and arbor eal gleaning insectivores: Thamnophilidae and Furnariidae. Secondary forest communities have the same number of sallying insectivores as Sinnamary and Riparian forests, but high numbers of nectarivores and omnivores as well. Ridge forests have a relative high number of woodpeckers, and Riparian forests have relatively high numbers of woodcreepers, which are the other group of species in the bark-dwelling insectivore guild. Granivores: Columbidae and Emberizinae are present in areas with large patches of grass found mainly in Secondary and Ridge forests.

Species diversity along the Sinnamary river. The five dominant species for each habitat point out the importance of frugivores (4 species) and terrestrial insectivores (4 species) in the understory bird communities (Table 3). Insectivores and frugivores are the main guilds in Primary, Sinnamary and Riparian forests; in Secondary forest, all the guilds are well represented, but in Ridge forest a nectarivore is ranked first. Among frugivores, *Pipra serena* and *P. pipra* are species of Primary and Secondary habitats; *P. aureola* is specific to Riparian and Ridge forest. The bark-dwelling woodcreeper, *Glyphorynchus spirurus*, was captured everywhere but it is scarce in the Ridge forest, it is the dominant species in Riparian forest. Three terrestrial insectivores: *Pithys albifrons*, *Gymnopithys rufigula* and *Hylophylax poecilonota* are the main species in the Primary and Sinnamary forests; *P. albifrons* is also important in the Secondary forest, but the three species are not present among the species captured in Ridge and Riparian forests. In each habitat, dominant species of nectarivores

are different; the hermits *Phaethornis supercilliosus* and *Glaucis hirsuta* are present in Secondary forest; others hummingbirds like *Thalurania furcata* occur in Primary and Sinnamary forests, *Amazilia leucogaster* is the dominant species in Ridge forest. The omnivore-frugivore *Ramphocelus carbo* is a dominant bird in Secondary forest and in Ridge forest, but there is a bias for this species as, when a bird is caught, its distress calls often stimulate the capture of other members of the flock. Among the eleven species of Furnariidae, only one was captured in the Riparian forest (*Philydor ruficaudatus*) and one in the Ridge forest (*Synallaxis guyanensis*). A jacamar was captured in Primary forest: *Galbula albirostris*, and another one, *G. galbula* in Riparian and Ridge forest. On the waterlogged soil of Riparian forest, 8.9% of the birds captured were the small kingfisher, *Chloroceryle aena*.

DISCUSSION

Limits of the methodology. Pardieck & Waide (1991) point out that 36 mm mesh nets more often caught species weighing more than 26g. We found that with the 19 mm nets, 21% of the birds we captured weighed more than 26 g, reaching 145 g for *Momotus momota*, 155 g for *Micrastur gilvicollis* and 180 g for *Leptotila* spp. The 19 mm mesh can catch birds of a wide scale of masses but, for the large birds, sampling is biased as it is surely less effective than the 36 mm mesh nets.

Mist nets provide a biased sample for most communities, and may capture no more than 40% of the species present in a tall forest, even when the sample is very large (Terborg 1977, 1985). The main condition to be met in order to achieve a good capture rate of large birds is that the nets are checked very often because some big birds are able to tear the nets with their momentum. The comparison between the habitats is based on identical sampling provided by the mist-nest technique.

We have determined that in regard to the number of hours of capture for 100 m mist-nets, the cumulative curve shows a plateau at 50–60 species recorded in 50–100 h. To capture 10 more species the capture effort (i.e., the number of capture hours for 100 m nets), would have to have a 10 fold increase. There is an important decrease in the number of captures in the same nets after 20 h; so to have a good representation of the bird communities for an habitat, an accurate method is either to have different netting sessions at intervals of at least two or three weeks at the same place, or to change the placement of the mist-nets in the same habitat.

The change of placement was done for the Primary forest where data are presented from five capture sessions in five different sites (P1 to P5). The data for the other habitats are a combination of sessions in the same location from one site (Ridge forest and Secondary forest) to two sites (for the other habitats) during less than a year. Inter-seasonal changes in avifauna composition occurred when the same site is used at different time of the year. Five netting sessions from April 1994 to July 1995 were set on site S3 (Table 1). Four netting sessions from December 1994 to august 1995 were set on site E2. Three netting sessions from February to August 1995 were set on site R3, from December 1993 to October 1994 were set on sites B2 and B3. On Figure 1, each of these seasonal sampling show a change with the other ones. But at the scale of the inter-habitats avifauna composition, these intra-site seasonal changes are not important enough to interfere with the main community composition comparisons.

The principal component analysis shows for each habitat some marked differences in the particular understory bird community composition. The habitats are ranked in

order according to their position along the Sinnamary river from Sinnamary forest to Ridge forest (Fig. 1). The Sinnamary forest understory bird composition is almost identical to the reference Primary forest. Downstream changes occur, allowing an identification of each forest by some stable components of its avifauna (Greenberg & Gradwohl 1986). The similarity of Sinnamary (B)and Secondary (S) forest habitat is mainly due to localisation of site S3 at the edge of a primary forest, and thus that there are some exchanges between these two forest types. Sites S1 and S2 are located 500 m from primary forest and have a very different community composition from the Sinnamary forest.

For four habitats we collected more than 49 species. The Riparian forest had only 39 species. This large difference in the number of species, is highly significative in this study; it can be used as a first point of comparison between habitats as the capture effort in Riparian forest was of 909 net-h, and in the Ridge forest 49 species were collected for a capture effort of only 450 net-h.

Biomass distribution. The distribution of body size among species did not differ significantly between the five habitats. The assertion that average body mass varies with the habitat type (Cotgreave & Harvey 1994), with larger birds being found in simpler habitats, cannot be tested with the technique used here as the larger categories (more than 256 g) are not captured. The low mean in Ridge forest is due to the large number of light weight (4.2 g) *Amazilia leucogaster* captured. Cumulative curves, daily activities and biomasses are not very different between the habitats. The differences revealed by the principal component analysis are analysed at the nutritional guild level and then at the species level.

Feeding guild composition. The dominance of insectivore guilds in Primary forest is also significant in the Sinnamary forest with an increase of omnivorous birds showing the use of the river as a corridor. The other three forests show a significant relative distribution by guild: Riparian forest is mainly composed of frugivores and arboreal, gleaning insectivorous; the main guild in Secondary forest is omnivorous; in the Ridge forest the almost equal biomass between granivores, sallying insectivores, bark-dwelling insectivores, arboreal insectivores and omnivores is correlated with the wide food possibilities provided by the combination of low bushes, Cactacae and large trees 15–25 m high.

Aerial-salliers (IA) are of relative equal importance in all habitats. Nectarivores and granivores are almost absent in Riparian forest because the wet or waterlogged soil of this type of forest does not provide enough flowers and seed; they are mainly founds in the canopy.

Another difference between the forest habitats is that 72 species (46%), were captured in only one habitat (Table 2). Specificity to a particular habitat is marked mainly for granivores (six of the seven species were found only in one habitat), omnivores(67%), bark-dwelling insectivores (58%) and sallying insectivores (57%).

The ratio for the number of species found in each habitat and the number of species found only in one habitat is about the same for Primary, Sinnamary and Secondary forest (21 to 25%). It is 7% for the Riparian forests, meaning that only the most common species were captured in this area. In the Ridge forest, 29% of the species were not found in other habitat: three of four Picidae were caught only in this habitat as well as seven species of sallying insectivores.

Juanes (1986), Cotgreave & Harvey (1991, 1992) have shown that guild structure is associated with the commonness and rarity of different bird species within local communities. The basic composition of the understory avi-

fauna along the Sinnamary river is of two frugivores, two bark-dwelling insectivores, three arboreal gleaning insectivores and two omnivores-frugivores.

Species diversity along the Sinnamary river valley. In Primary and Sinnamary forests, 12 common insectivore species are found only in these habitats: six arboreal gleaning insectivores, five sallying insectivores and *Hylophylax naevia*, a terrestrial insectivore.

Due to the various stages of growth occurring in the Secondary forest habitat, there is no common species that is restricted to this habitat: among the 41 species selected as common, 26 live also in at least two other habitats. In regard to bird diversity, the Secondary forest, supplying a wide display of food and ecological niches, is a bridge between varied kinds of forests. Birds that were more abundant in Riparian forest include *Thamnomanes ardesiacus*, and manakins: *Pipra erythrocephala*, *Manacus manacus*, *P. aureola* and *Schiffornis turdinus*.

The Green-tailed Jacamar (*Galbula galbula*), White-lined Tanager (*Tachyphonus rufus*) and Trochilidae such as *Amazilia leucogaster*, *Chlorestes notatus* and *Anthracorax nigricollis* complete the main species captures in the Ridge forest.

A correspondence analysis (Fig. 2) on the relative density of the understory avifauna shows the high degree of relationship between Sinnamary forest and the reference Primary forest: they have 39 species in common with about the same densities. They also have 26 species in common with the Secondary forest, 13 in common with the Riparian forest and only five with the Ridge forest. Seventeen species are common to Ridge and to Riparian forest and 14 to Ridge and to Secondary forest. Only ten species found in Ridge forest were present in at least two of the other forest types, 20 species were unique to this habitat.

Manacus manacus, *Glyphorynchus spirurus*, *Myrmotherula axillaris*, and R*amphocelus carbo* are ubiquitous species; *Pipra erythrocephala*, *Myrmotherula menetriesii*, *Schiffornis turdinus*, *Philydor ruficaudatus*, *Thamnomanes ardesiacus* and *Xyphorhynchus pardolatus*, are present in four habitats. Considering that the Primary and Sinnamary forest communities are almost identical, *Thamnophilus punctatus*, *Mionectes oleaginea*, *Myrmotherula guttata* can be added to this list.

The highest diversity is found in the Secondary forest, and it has the highest number of species that were also captured in other habitats.

Birds are environmental indicators, both at the level of the guild composition and at the level of species specificity. These striking changes in the structure of forest understory avifauna along a river stream should not be extrapolated to all species and guilds if the data are not collected with the same methodology .

It will be very interesting to follow the effects on the composition of the understory avifauna, during the water logging of the Petit-Saut dam then after the total filling up.

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APPENDIX. Population data for the 155 species captured in the five habitats. N: number of captures; d: number of individuals per 100 h of mist-netting sessions per 100 m nets. The checklist follows Meyer de Schauensee & Phelps (1978) and Tostain *et al.* (1992). Guild and biomass are from Terborgh et al. (1990), Thiollay (1986), Blake & Loiselle (1991) and this study.

FH: piscivore; CN: raptor; FA: arboreal frugivore; GR: arboreal, terrestrial and grass granivore; IA: arboreal, sallying insectivore (species that hawk, hover, snatch or strike, Firtzpatrick, 1981); IB: bark-dwelling insectivore feeding in trunk interior (woodpeckers) or superficially (some dendrocolaptids or furnariids); IF: arboreal, gleaning insectivore; IT: gleaning terrestrial or ant-following insectivore; NI: nectarivore-insectivore (not only hummingbirds); OA: predominantly insectivore.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
FALCONIDAE													
Micrastur gilvicollis	CN	155			1	0.5							1
COLUMBIDAE													
Columbina passerina	GR	37									7	10.2	7
Leptotila verreauxi	GR	170							1	1.4	3	4.4	4
Leptotila rufaxilla	GR	180			1	0.5	1	0.6					2
Geotrygon montana	GR	125					3	1.9					3
CUCULIDAE													
Piaya minuta	IF	42									1	1.5	1
CAPRIMULGIDAE													
Caprimulgus cayennensis	IT	44					1	0.6					1
TROCHILIDAE													
Glaucis hirsuta	NI	6.4					16	10.1					16
Threnetes niger	NI	6					1	0.6					1
Phaethornis superciliosus	NI	5.4	4	3	4	2	13	8.2					21
Phaethornis malaris	NI	3.5	1	0.8									1

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
Phaethornis bourcieri	NI	4	5	3.8	7	3.5	6	3.8					18
Phaethornis longuemareus	NI	4			2	1			1	1.4			3
Campylopterus largipennis	NI	7.8	9	6.8	5	2.5	10	6.3					24
Florisuga mellivora	NI	6.5			1	0.5	1	0.6					2
Anthracorax nigricollis	NI	6.5					1	0.6			1	1.5	2
Anthracothorax viridigula	NI	6									1	1.5	1
Chrysolampis mosquitus	NI	3.8									4	5.8	4
Chlorestes notatus	NI	4.3					5	3.2			6	8.7	11
Chlorostilbon mellisugus	NI	3.2			1	0.5					2	2.9	3
Thalurania furcata	NI	3.8	16	12	5	2.5	5	3.2					26
Hylocharis sapphirina	NI	4.3					3	1.9					3
Polytmus theresiae	NI	3.9					1	0.6			4	5.8	
Amazilia fimbriata	NI	4.8			1	0.5			1	1.4			2
Amazilia leucogaster	NI	4.2							2	2.7	43	62.4	45
TROGONIDAE													
Trogon violaceus	IS	44			1	0.5							1
ALCEDINIDAE													
Chloroceryle aena	FH	14	3	2.3	1	0.5			13	17.8	3	4.4	20
MOMOTIDAE													
Momotus momota	OA	145			3	1.5	1	0.6					4
GALBULIDAE													
Galbula albirostris	IS	19	1	0.8	2	1							3
Galbula galbula	IS	26							5	6.9	5	7.3	10
BUCCONIDAE													
Malacoptila fusca	IS	41	1	0.8									1
PICIDAE													
Picumnus exilis	IB	9.5									1	1.5	1
Picumnus spilogaster	IB	15									1	1.5	1
Veniliornis passerinus	IB	30							2	2.7			2
Veniliornis cassini	IB	26									1	1.5	1

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
FURNARIIDAE													
Synallaxis guyanensis	IF	18					1	0.6			2	2.9	3
Philydor ruficaudatus	IF	30	1	0.8	1	0.5	2	1.3	2	2.7			6
Philydor erythrocercus	IF	28	1	0.8			2	1.3					3
Philydor pyrrhodes	IF	34			1	0.5							1
Automolus infuscatus	IF	2	1.5	2	1								4
Automolus rubiginosus	IF	38	1	0.8	1	0.5	1	0.6					3
Sclerurus mexicanus	IF	23	4	3									4
Sclerurus rufigularis	IT	21			1	0.5							1
Sclerurus caudatus	IT	38			4	2							4
Xenops tenuirostris	IB	12	1	0.8									1
Xenops minutus	IB	13			3	1.5	1	0.6					4
DENDROCOLAP-TIDAE													
Dendrocincla fuliginosa	IS	44			11	5.5	3	1.9					14
Dendrocincla merula	IT	30	2	1.5									2
Deconychura longicauda	IS	36	2	1.5	2	1							4
Deconychura stictolaema	IB	14			2	1							2
Glyphorynchus spirurus	IB	14	9	6.8	24	12	13	8.2	16	21.9	1	1.5	63
Dencrocolaptes certhia	IS	60	1	0.8	1	0.5			2	2.7			4
Xiphorynchus picus	IB	42							2	2.7	3	4.4	5
Xiphorhynchus pardalotus	IB	36			2	1	2	1.3	2	2.7			10
Xiphorhynchus guttatus	IB	44	4	3	2	1			1	1.4	2	2.9	5
Campylorhamphus trochi-lirostris	IB	33			2	1							2
THAMNOPHILIDAE													
Sakesphorus canadensis	IF	28							3	4.1	3	4.4	6
Thamnophilus doliatus	IF	30					1	0.6	3	4.1	7	10.2	11
Thamnophilus nigrocinereus	IF	16					1	0.6	1	1.4			2
Thamnophilus punctatus	IF	22			2	1	1	0.6	5	6.9	2	2.9	10
Thamnophilus amazonicus	IF	22	2	1.5									2

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
Thamnomanes ardesiacus	IS	17	5	3.8	2	1	4	2.5	4	5.5			15
Thamnomanes caesius	IS	17	6	4.5	5	2.5	2	1.3					13
Myrmotherula brachyura	IF	11			1	0.5							1
Myrmotherula guttata	IF	11	4	3			3	1.9	4	5.5			11
Myrmotherula gutturalis	IF	8.5			3	1.5	1	0.6					4
Myrmotherula axillaris	IF	7.5	6	4.5	2	1	1	0.6	5	6.9	1	1.5	15
Myrmotherula longipennis	IF	8.5	9	6.8	3	1.5	1	0.6					12
Myrmotherula menetriesii	IF	8	3	2.3	3	1.5	1	0.6	1	1.4			8
Formicivora grisea	IT	13							6	8.2	10	14.5	16
Hypocnemis cantator	IF	12	2	1.5	4	2							6
Hypocnemoides melanopogon	IF	13	1	0.8					5	6.9			6
Percnostola rufifrons	IF	28	6	4.5	1	0.5			4	5.5			11
Percnostola leucostigma	IF	32	1	0.8									1
Myrmeciza ferruginea	IF	27	9	6.8	2	1	2	1.3					13
Myrmeciza atrothorax	IF	24							1	1.4			1
Pithys albifrons	IF	21	17	12.8	72	35.9	21	13.2					110
Gymnopithys rufigula	IT	29	9	6.8	20	10	5	3.2					34
Hylophylax naevia	IT	13	3	2.3	3	1.5							6
Hylophylax poecilonota	IT	17	12	9	9	4.5	2	13					23
Myrmornis torquata	IT	37	1	0.8	3	1.5	1	0.6					5
FORMICARIIDAE													
Formicarius colma	IT	13	1	0.8									1
CONOPOPHAGIDAE													
Conopophaga aurita	IT	23	1	0.8									1
COTINGIDAE													
Phoenicircus carnifex	OA	103					3	1.9					3
PIPRIDAE													
Pipra erythrocephala	FA	12	7	5.3	8	4	10	6.3	4	5.5			29
Pipra pipra	FA	11	35	26.3	52	25.9	28	17.6					115
Pipra serena	FA	11	16	12	28	13.9	18	11.3					62

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
Pipra aureola	FA	15					2	1.3	12	16.4	25	36.3	39
Corapipo gutturalis	FA	12	1	0.8									1
Manacus manacus	FA	16	6	4.5	1	0.5	8	5	10	13.7	1	1.5	26
Schiffornis turdinus	FA	32	1	0.8	6	3	2	1.3	2	2.7			11
TYRANNIDAE													
Zimmerius gracilipes	OA	8			3	1.5							3
Phaeomyias murina	IS	10					3	1.9			20	29	23
Tyrannulus elatus	IF	7							1	1.4	2	2.9	3
Myiopagis flavivertex	IF	20									2	2.9	2
Elaenia flavogaster	IF	24					1	0.6			3	4.4	4
Elaenia parvirostris	IF	22									2	2.9	2
Inezia subflava	IS	11							3	4.1			3
Mionectes oleaginea	OA	13			9	4.5	4	2.5	7	9.6			20
Mionectes macconnelli	IS	12	9	6.8			8	5					17
Phylloscartes virescens	IF						1	0.6	1	1.4			2
Corythopis torquata	IT	16	1	0.8									1
Lophotriccus galeatus	IA	7					1	0.6					1
Poecilotriccus fumifrons	IS	6.3					4	2.5					4
Todirostrum maculatum	IS	7					2	1.3			3	4.4	5
Ramphotrigon ruficauda	IS	17					1	0.6					1
Rhynchocyclus olivaceus	IF	18					1	0.6					1
Tolmomyias sulphurescens	IS	11									2	2.9	2
Tolmomyias assimilis	IS	14					1	0.6					1
Platyrinchus saturatus	IF	11	3	2.3			3	1.9					6
Platyrinchus coronatus	IF	9	7	5.3	10	5							17
Onychorhynchus coronatus	IS	13	1	0.8									1
Terenotriccus erythrurus	IS	7.2			2	1							2
Myiobus barbatus	IS	11	9	6.8	5	2.5							14
Myiophobus fasciatus	IS			1	0.5								1
Cnemotriccus fuscatus	IS	13									1	1.5	1

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
Attila cinnamomeus	IS	40									1	1.5	1
Attila spadiceus	IS	35					2	1.3	1	1.4			2
Laniocera hypopyrrha	OA	48	1	0.8									1
Myiarchus ferox	IS	26									1	1.4	1
Myiarchus tyrannulus	IS	28									2	2.9	2
Myiozetetes cayanensis	IS	24									1	1.5	1
Pachyramphus polychopterus	IA	22									2	2.9	2
TROGLODYTIDAE													
Thryothorus coraya	IF	18			3	1.5	2	1.3	2	2.7			7
Microcerculua bambla	IT	17			4	2							4
Cyphorhinus aradus	IT	20	1	0.8									1
SYLVIIDAE													
Microbates collaris	IF	9.5	4	3	1	0.5							5
Ramphocaenus melanurus	IF	9.2					1	0.6					1
TURDIDAE													
Turdus leucomelas	OA	69					4	2.5	2	2.7	1	1.5	7
Turdus nudigenis	OA	60					2	1.3					2
Turdus albicollis	OA	49	4	3	12	6	13	8.2					29
VIREONIDAE													
Vireo olivaceus	IF	14					2	1.3					2
Hylophilus pectoralis	IF	12									3	4.4	3
Hylophilus ochraceiceps	IF	10	5	3.8	1	0.5	2	1.3					8
PARULIDAE													
Dendroica petechia	IF	9									3	4.4	3
Seiurus noveboracensis	IT	16									1	1.5	1
Basileuterus rivularis	IT	12							2	2.7			2
ICTERIDAE													
Icterus nigrogularis	OA	37									2	2.9	2
EMBERIZIDAE													
Coereba flaveola	FA	11	1	0.8			1	0.6					2

APPENDIX. Continuation.

	Guild	Mass (g)	Primary f.		Sinnam. f		Second. f.		Riparian f.		Ridge f.		Total birds
			N	d	N	d	N	d	N	d	N	d	
Dacnis cayana	OA	12			1	0.5							1
Cyanerpes caeruleus	OA	13			1	0.5							1
Cyanerpes cyaneus	OA	12					2	1.3					2
Conirostrum bicolor	IF	11									10	14.5	10
Thraupis episcopus	OA	36					3	1.9			1	1.5	3
Thraupis palmarum	OA	34					2	1.3					2
Ramphocelus carbo	OA	26	1	0.8	2	1	16	10.1	6	8.2	8	11.6	28
Tachyphonus rufus	IF	35					1	0.6			1	1.5	2
Tachyphonus surinamus	IF	23	7	5.3	5	2.5	3	1.9					15
Cyanocompsa cyanoides	IS	25	3	2.3	1	0.5							4
Saltator maximus	OA	39			1	0.5							1
Periporphyrus erythromelas	OA	45			3	1.5							3
Aremon taciturnus	OA	25							1	1.4			1
Oryzoborus angolensis	GR	13	2	1.5									2
Sporophila castaneiventris	GR	9					1	0.6			3	4.4	4
Volatina jacarina	GR	10					5	3.2					5
Number of captures			291		389		303		146		215		1336
Net-hours				1103		1585		1671		909		450	
Nb. captures/net-h				0.26		0.25		0.18		0.16		0.48	
Number of species			60		68		74		39		49		155
Total biomass (g)				4557		7967		6096		2888		3641	
Biomass (g) per net-hour				4.13		5		3.7		3.2		8.1	