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BIRDS OF THE TAPAJOS NATIONAL FOREST, BRAZILIAN AMAZON: A PRELIMINARY ASSESSMENT

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Resumo. – Aves da floresta nacional do Tapajós, Amazônia Brasileira: Uma análise preliminar. – Este estudo descreve a avifauna da Floresta Nacional do Tapajós, uma área situada na margem direita do Rio Tapajós onde ocorre exploração controlada recursos. Nós apresentamos uma lista quase completa das espécies da floresta de *terra firme* e uma lista incompleta das espécies de hábitats menos extensivamente amostrados, tais como a floresta de "várzea". Nós documentamos a avifauna nuclear da floresta de *terra firme* e caracterizamos a avifauna de sub-bosque de floresta de *terra firme* através de amostras em redes de captura. A lista de aves da floresta nacional, obtida ao longo de um período de nove anos, compreende 342 espécies, das quais 59% foram documentadas através de pelo menos um espécime, ou fotografia ou gravação. Deste total, 274 espécies constituíram a avifauna nuclear de floresta de *terra firme*, uma riqueza de espécies comparável aos totais observados em outros sítios de floresta de *terra firme* na Amazônia. Os resultados das redes de captura em floresta de *terra firme* indicam uma riqueza, baseada sobre procedimentos jackknife, da ordem de 109–149 espécies de sub-bosque. Espécies raras predominaram nas amostras de rede, de tal maneira que 90% das 114 espécies de uma amostra de 1612 indivíduos foram consideradas raras (definida como ≤ 2% da amostra). Nossa amostra foi similar as amostras de redes de outras florestas Neotropicais tanto na relação das espécies mais freqüentemente capturadas como na organização trófica. Tal como em amostras de rede de outros sítios de floresta de *terra firme* na Amazônia, capturas de nectarívoros e frugívoros foram especialmente baixas. Como tem sido sugerido previamente, isto pode refletir a baixa produtividade das plantas do sub-bosque.

Abstract. – This study describes the avifauna of the Tapajós National Forest, an area on the east bank of the Tapajós River where controlled resource exploitation occurs. Here we provide a nearly complete species list for *terra firme* forest with an incomplete list of species from less comprehensively surveyed habitats such as "várzea" forest. We document the core avifauna of *terra firme* forest and characterize net samples of *terra firme* forest understory birds. The national forest list obtained over a 9-year period includes 342 species, of which 59% were documented with at least a specimen, photo or tape. Of this total, 274 species constitute the core avifauna of *terra firme* forest, a species richness comparable to totals from other Amazonian *terra firme* sites. Netting results from *terra firme* forest indicate a total understory species richness of 109–149 species based on jackknife procedures. Rare species predominated in the net sample, as 90% of 114 species in a sample of 1612 individuals were rare (defined as ≤ 2% of the sample). Our sample was

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similar to other Neotropical forest net samples in the most frequently captured species and trophic organization. As with other Amazon *terra firme* forest net samples, nectarivore and frugivore captures were especially low. As has been suggested previously, this may reflect low understory plant productivity. *Accepted 25 October 2002.*

Key words: Neotropical birds, *terra firme* forest, Amazonia, Tapajós National Forest, Brazil, mist net, bird communities.

INTRODUCTION

Detailed knowledge of the avifaunas of continental Neotropical forests is limited to relatively few sites where long-term studies have been conducted. These studies have resulted in species lists documenting the "core" species of a site (excluding occasional, dispersing or wandering individuals; Remsen 1994) thereby enabling researchers to characterize the avifauna's taxonomic affinities, guild structure, and seasonality (Bierregaard 1990, Blake *et al.* 1990, Karr *et al.* 1990, Robinson *et al.* 2000). Although a thorough species list for a site is a prerequisite for most biogeographic and community studies, as well as for conservation purposes, such lists for continental Neotropical forests are rare because of logistical constraints imposed by high species richness. This is especially true in the Amazon basin where relatively comprehensive species lists are available for only a few sites (e.g., Manu National Park, Peru, Karr *et al.* 1990; Tambopata Nature Reserve, Peru, Parker *et al.* 1994; Manaus, Brazil, Karr *et al.* 1990, Cohn-Haft *et al.* 1997; Jaú National Park, Brazil, Borges *et al.* 2001), further emphasizing the need for basic avifaunal surveys in Amazonia (Oren & Albuquerque 1991).

The Tapajós National Forest, on the east bank of the Tapajós River, south of Santarém, Brazil, is a site for which a basic description of the avifauna is lacking. A description of the national forest's avifauna is useful for management and provides a baseline for future comparisons, as selective logging continues within the forest and deforestation accelerates along the forest's borders. In addition, these studies provide a basis for comparison with other lowland Neotropical sites, particularly upland or *terra firme* forests. The purpose of this study is to describe the avifauna of the Tapajós National Forest by providing a species list, identifying the core avifauna of *terra firme* forest and characterizing the *terra firme* forest understory bird assemblage as sampled by mist nets.

Surveys of the Tapajós birds were conducted over a 9-year period and involved a variety of sampling methods, resulting in documentation of species presence based on specimens, photographs, and tape recordings, as well as records based on sight or sound. Although we are confident that most of the core avifauna of *terra firme* forest in the Tapajós National Forest has been documented, the list for the entire national forest should be viewed as preliminary given limited sampling of the geographic extent of the national forest and under-representation of some habitats such as the seasonally flooded forest.

STUDY AREA

The study was conducted in the 560,000-ha Tapajós National Forest (henceforth FLONA Tapajós), a unit in the national forest system of Brazil managed by Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renovaveis (IBAMA). The FLONA Tapajós (20°45'S, 55°00'W) is located on the right bank of the lower Tapajós River near the mouth of the Tapajós River in the western

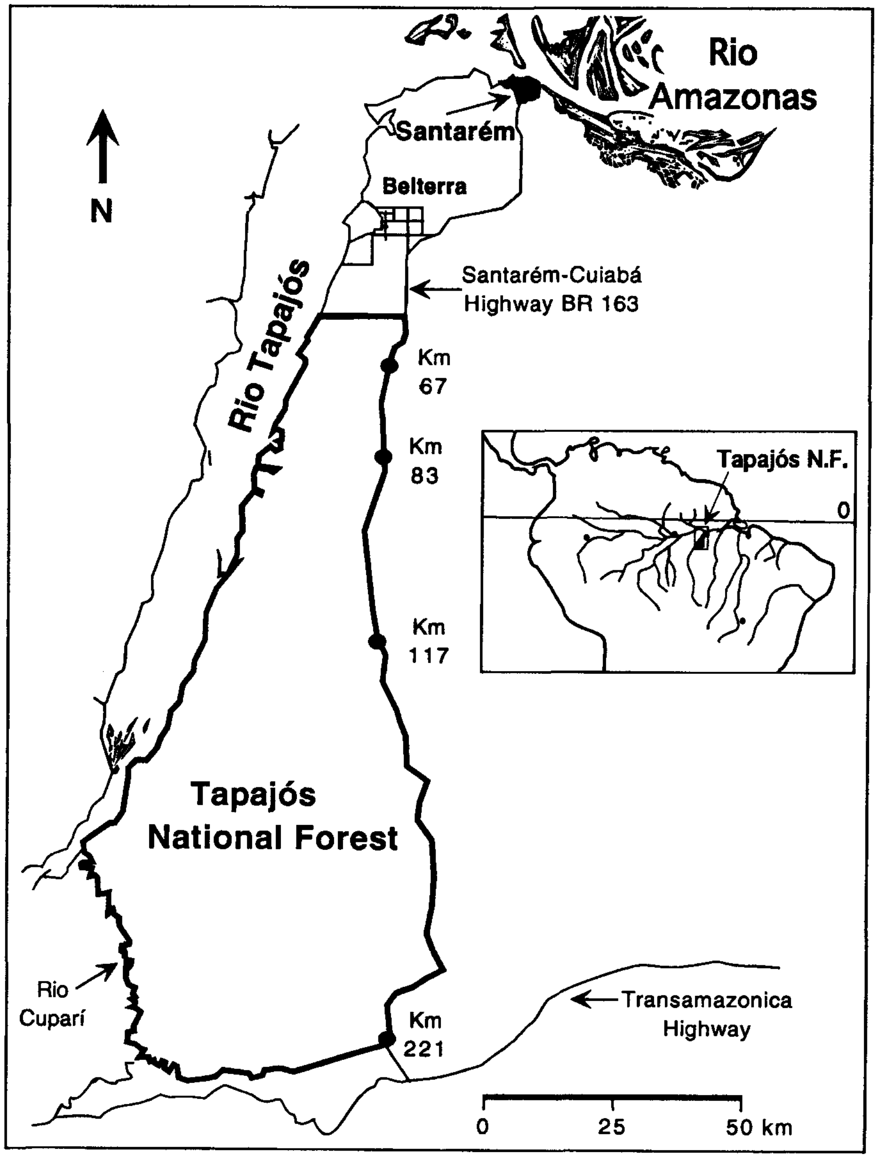

FIG. 1. Location of the Tapajós National Forest, in Pará Brazil. Map of the national forest shows locations along the Santarém-Cuiabá highway (Km 67, 83, and 177) where the national forest was entered for avian studies.

part of the state of Pará. It is bounded by the Tapajós River to the west, the Santarem-Cuiabá Highway (BR-163) to the east, and Cupari River to the south (Fig. 1).

The climate of the FLONA Tapajós has been briefly described by Parrotta *et al.* 1995, who note that the national forest has a mean annual temperature of 25°C and a mean relative humidity of 86%. Annual rainfall averages approximately 1920 mm, with a short dry season of 2–3 months, usually between August and October, during which monthly precipitation is less than 60 mm a month.

The forests of the region, including the FLONA Tapajós and status of botanical inventories, have been summarized in Daly & Prance (1989). Studies of forest structure and floristics in the FLONA are cited in Parrotta *et al.* (1995). Several distinct moist and wet forest types are found within the boundaries of the FLONA Tapajós, with *terra firme* forest constituting approximately 33% of the forest area. Our netting study was conducted in *terra firme* forest on gently undulating upland terrain characterized by emergent species such as *Bertholletia excelsa*, *Couratari* spp., *Dinizia excelsa*, *Hymenaea coubaril*, *Manilkara huberi*, *Parkia* spp., *Pithecellobium* spp. and *Tabebuia serratiolia* (Silva *et al.* 1985). Canopy heights of undisturbed forests range from approximately 30 to 40 m, with occasional emergent species reaching approximately 50 m.

Our avian surveys were concentrated in a few locations in the FLONA Tapajós accessible by roads entering the forest at km 67, 83, and 117 along the Santarém-Cuiabá Highway (Fig. 1). Some observations and recordings were also made on the forest edge and second growth along the Santarém-Cuiabá Highway from km 50 to km 117. In addition, observations and recordings were made of birds in and along a small stream ("igarapé") with a moderate sized open water pool with emergent vegetation along the Santarém-Cuiabá Highway, just south of km 83. However, most of our surveys were concentrated in the *terra firme* forest that was accessible by a road entering the FLONA Tapajós at km 83, where a system of roads and trails provides access to the forest. Here our surveys mostly occurred on a 5000-ha grid (3°21'21"S, 54°56'58"W) established for demonstration forestry in *terra firme* forest. We estimate that at least 85% of our bird watching, recording, and netting activities occurred in the 5000-ha grid.

As part of our avian surveys a small net sample was obtained in the *terra firme* forest at km 117. However, our intensive netting study occurred in the *terra firme* forest on the 5000-ha grid at km 83. Here our netting study was conducted in two 100 ha control blocks (C-1 and C-3). The two control blocks were completely surrounded by forest and separated from each other by another 100 ha control block. Low impact selective logging with a harvest rate of 18 m^3/ha occurred on the grid in October to December 1997. The nearest logged block was located approximately 2.5 km to the north of C-3. Each control block is dissected by a small stream. Forests covering the two blocks consisted of undisturbed primary forest, except for an estimated 25% of C-1 that was old secondary growth (30–40 years old).

METHODS

Avian species inventory. A variety of methods were used to observe, identify, and collect birds in the FLONA Tapajós to produce a species list (Appendix 1). Voucher specimens of some species were collected with mist nets or shotgun. All specimens were deposited in the Museu Paraense Emílio Goeldi in Belém. Tape recorders with directional microphones were used to record and identify birds and tape playback was sometimes used successfully to attract and visually identify certain species. Tapes of all vocalizations are currently in the possession of the first author, but will be deposited in the tape collection of the Arquivo Sonoro Neotropical, Universidade de Campinas, Campinas, São Paulo. Binoculars (10 x 40) and rarely a spotting scope (20 x) were used to observe and identify birds as we walked slowly through the forest in search of birds. Although most of our bird observations occurred in the period shortly after sunrise (06:00 to 10:00 h), observations were made throughout the day including searches for nocturnal species at night.

Our initial avian observations in the FLONA Tapajós occurred during 12–15 June 1992 and 14–20 September 1993, and were followed by visits of longer duration associated with our netting studies (see below). During all netting sessions, both observations and tape recordings of vocalizations were made to verify species' presence. A 45 m canopy tower, at km 67 was used for a few morning observations of canopy birds (12 July 2000; 9 December 2000, 26, 27, 28 June 2001).

Following Cohn-Haft *et al.* (1997), we determined species' abundance subjectively, using status categories to reflect actual population density in preferred habitat. This involved subjectively combining frequency of detection (auditory or visual) and capture rate to derive a species' status. As recommended by Cohn-Haft *et al.* (1997), these categories should be treated as tentative assessments of abundance and should be validated with quantitative techniques (e.g., Terborgh *et al.* 1990). The designation "common" refers to a species believed to occur everywhere (e.g., contiguous territories) in appropriate habitat. The category "uncommon" refers to species that occur in most, but not all appropriate habitats (e.g, vacant habitat between territories), and may have densities approximately an order of magnitude lower than common species. Species that are absent from more appropriate habitat than in which they occur, and have densities an order of magnitude lower than uncommon species are designated as "rare". Species in any of these three status categories are considered to be part of the "core avifauna" (Remsen 1994). Finally, "casual" refers to species detected only three or fewer times. Species designated as "casual" may be either low-density or sporadic residents or vagrants. For species with seasonal changes in abundance, the status designation is based on the period of highest abundance. Those species with seasonally variable abundance were designated as "boreal migrant" if present only during October–April and as "austral migrant" if present only during April–September.

Both habitat and microhabitat associations were determined for each species. *Terra firme* refers to upland primary forest. Second growth included both young and older second growth areas, as well as forest edge along the Santarém-Cuiabá road. Pasture included areas with widely scattered remnant trees. Plantations included small areas of cultivated rice, corn, or manioc. Open areas included regions around houses and settlements, usually with cultivated fruit trees. A riparian area included a small stream (igarapé) with a moderate-sized open water pool with emergent aquatic vegetation. Within these six habitat categories, we recognized eight microhabitats: terrestrial (i.e., ground forager), understory, midstory, canopy, aerial, water surface or edge, forest edge, and treefall.

Sociality was categorized with the following designations: solitary or in pairs, monospecific flocks, understory heterospecific flocks, canopy heterospecific flocks, army antfollowers; and leks. Species designated as occurring in heterospecific flocks include both obligate flock joining species as well as casual species observed in flocks. Diet was based on primary observations and published literature [fruit, arthropods, mollusks, carrion, vertebrates, fish, seeds, nectar, and a combination of fruits, seeds, and arthropods (omnivore)]. The substrate where food is obtained was designated as: ground, live foliage, air, water, bark, or in association with army ants (ground or < 1 m from ground).

Following Cohn-Haft *et al.* (1997), we evaluated the evidence concerning the presence of each species in a hierarchical manner; only the highest quality evidence is indicated in Appendix 1. The best evidence for documentation of species presence is a specimen, followed by a permanent record by photograph or tape recording, either of which can be used to confirm species identifications. The third best evidence is a capture record, in which a bird is identified by sight with various measurements (e.g., wing chord, tail, and weight) confirming the identification. The lowest form of evidence of species presence is field identification based on sight or sound only. Thus species tallied by only sight or sound, in the absence of higher-level evidence, were listed as preliminary.

The first author was responsible for identification of most birds in the FLONA Tapajós, although the second author independently made sight and tape records verifying species presence as well as contributing records to the list. Additional records of species occurrences were provided by Sidnei de Melo Dantas and Curtis A. Marantz, as indicated in Appendix 1.

Several expert taxonomic sources were followed in this research. For the non-Passeriformes we followed Sick (1997), which was based on Meyer de Schauensee (1966, 1970) and American Ornithologists' Union (1983). For Passeriformes, we followed Ridgely & Tudor (1989, 1994), with minor modification as adopted by Sick (1997).

Understory mist net samples. Mist nets (36-mm mesh, 12 m x 2.8 m) were used to sample species for the inventory, as well as provided a sample from blocks C-1 and C-3 on the grid for detailed analysis as described below. Although most netting was conducted on the 5000-ha grid at km 83, some mist netting (approx. 720 net-h) occurred in the *terra firme* forest in the vicinity of the IBAMA guard station at km 117, during 16–21 August 1997, and from 17 August until 9 October 1999.

In addition to our mist net study in blocks C-1 and C-3 described below, mist netting was also used extensively in different *terra firme* sites on the 5000-ha grid at km 83 and contributed to the species inventory, by further documenting the presence of understory species. Concurrently with our netting study in blocks C-1 and C-3, we used mist nets to capture birds in two nearby selectively-logged blocks (T-2, T-18), using the same sampling design and net hours as described for the control blocks. In addition, a second netting study conducted in control blocks C-2 and C-3 and selectively logged blocks T-2 and T-18 was initiated in August 1999, and involved eight 16-day netting sessions through June 2001, totaling 24,864 net-h and 3965 captures.

Our study of blocks C-1 and C-3 involved two rows of six parallel net lines that were established in the center of each block. Net lines were separated by 200 m and contained 5 nets in a line, thereby sampling each block at 60 different net positions. A net line in each block was located 30 m from a small stream crossing each block. Five net lines in C-1 were located in old second growth forest.

Six net lines (i.e., 30 nets) in C-1 and C-3 were operated simultaneously for two consecutive days of a netting session from 06:00 to 15:00 h during which time nets were checked hourly. After the first six net lines were operated the nets were moved to the remaining six net line positions in a block where nets were opened for an equivalent duration. Thus each block required 4 days for a complete sample of the 12 net lines (60 nets) during a netting session. Data were collected during five netting sessions in the two blocks over a 23-month period including: August–September 1997, February–March 1998, November 1998, April 1999, and June 1999. The August–September 1997 and November 1998 session occurred during the dry season whereas remaining sessions occurred during the wet season.

All birds with the exception of hummingbirds, were marked with a numbered aluminum or a colored plastic band. We clipped a tail or wing feather of hummingbirds for identification during a netting session. Only one capture per individual was counted. All birds were identified to species, with age and sex determined when possible. Standard morphological measurements (wing chord, tail, and tarsus length) were taken upon first capture of an individual. Birds were weighed and checked for evidence of molt and breeding activity (brood patches) when first captured and during subsequent recaptures. A small voucher collection was made at the beginning of the study. Additional specimens were collected to confirm identities throughout the course of the study.

Species were assigned to guilds based on feeding, habitat and foraging substrate. This classification was based on that of Karr *et al.* (1990). To facilitate a comparison with the banding study in Manaus we used the same guild classification of Bierregaard (1990). In addition, to examine feeding guild variation between blocks and seasons (wet and dry), we classified birds using the diet classification provided in the appendix of Karr *et al.* (1990). These included the following categories: FR, fruits or fruits and seeds; LI, large insects; N, nectar and insects; SI, small insects; SO, small insects and fruit.

Species accumulation curves were derived from the cumulative number of unique individuals and not from the cumulative number of captures (which includes recaptures of individuals). A jackknife procedure, involving sampling with replacement for 1000 iterations was used to obtain robust estimates of species richness for samples of different sizes in the two blocks. A logistic equation was fit to the jackknife estimates to determine the asymptotic species richness.

Statistical analyses. Statistical analyses (Sokal & Rohlf 1995) were executed using SPSS (Norusis 1990). Rank-order abundance curves were derived for each of the two control blocks and were tested for independence using a row x column test of independence with a *G*-statistic. Log-linear models were used to test for significant interactions between various factors and the two control blocks. For example, interactions between species composition, season, and block were examined in which species composition included 22 species with adequate sample size, and wet and dry season captures in the two control blocks. Interactions between guild, season, and block were examined for the five guilds following the classification of Karr *et al.* (1990), in wet and dry season in the two control blocks.

RESULTS

Avian species inventory

A total of 342 species are currently known from the FLONA Tapajós (Appendix 1). Of the 342 species, 274 species constitute the "core" avifauna (*sensu* Remsen 1994) of *terra firme* forest.

Evidence. Of the 342 species listed in Appendix 1, 59% were documented by specimen (77), tape (103), photograph (10) or tape and photograph (10). Of the species not documented by specimen, photograph or tape, 33 were identified visually upon net capture, 90 were identified in the field by sight only, 5 were identified by vocalizations only, and 14 were identified by sight and vocalizations.

Mist net samples

After 23 months of banding (10,800 net-h) in the *terra firme* forest, 1885 captures of 1612 individuals representing 114 species were found in control blocks 1 and 3. This represents 84.6% of the species known from net samples from these blocks as well as an undis-

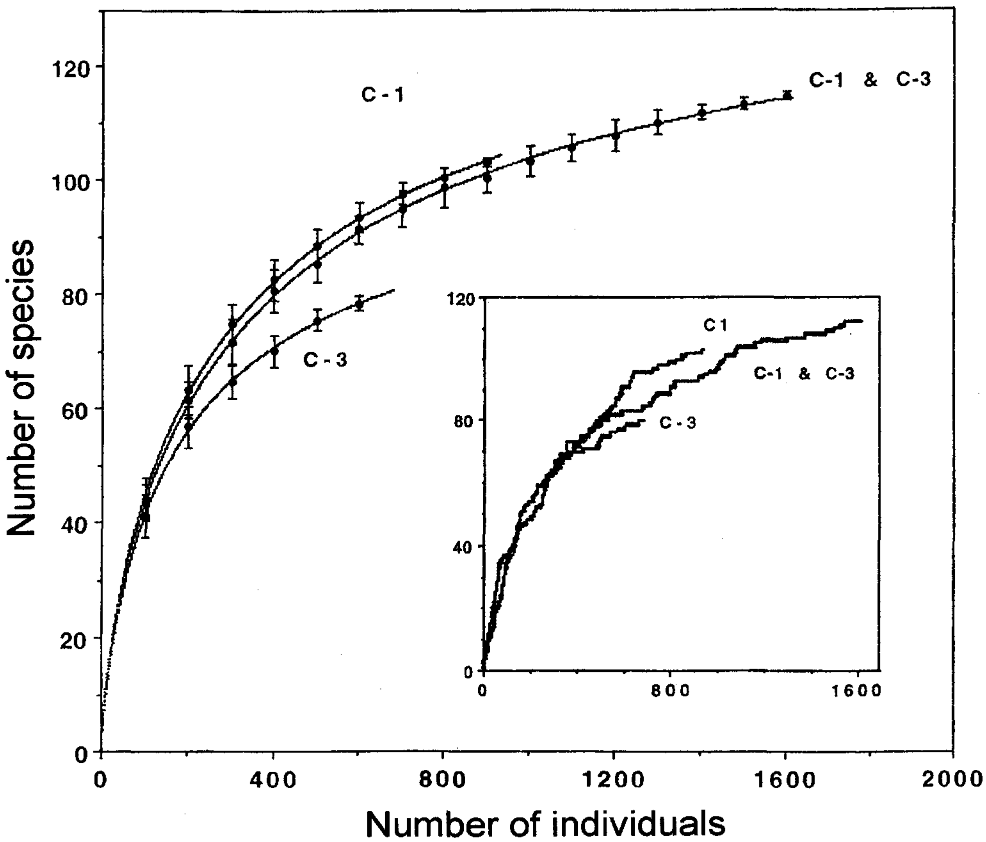

FIG. 2. Species richness relative to the cumulative number of sampled individuals estimated from a jackknife procedure involving sampling with replacement for understory mist-net samples in *terra firme* forest control blocks 1 and 3 in the Tapajós National Forest, Brazil. The inserted graph shows the observed relationship of species richness and the cumulative number of individuals captured in mist nets. C1 and C3 indicate control blocks 1 and 3, respectively. Error bars represent 1 SE.

turbed and two selectively logged blocks on the 5000-ha grid at km 83, and 41.6% of the 274 core species currently known from the *terra firme* forest in the national forest (Appendix 1).

The rate of species accumulation was highest in C-1, the block with some second growth vegetation (Fig. 2). The rate of species accumulation was highest in the first 400 to 500 individuals captured. The jackknife procedure predicted a species richness of 149 and 109 species for C-1 and C-3, respectively, assuming an infinite number of samples (Fig. 2). The procedure further indicated that a sample of 100 individuals from either control block would be expected to have approximately 40 species.

As with other avian understory assemblages in continental Neotropical forests the rank-ordered abundance distribution was strongly skewed towards rare species, with very few common species in either control block (Fig. 3). The most common species, *Glyphorynchus spirurus*, represented only 11.2%

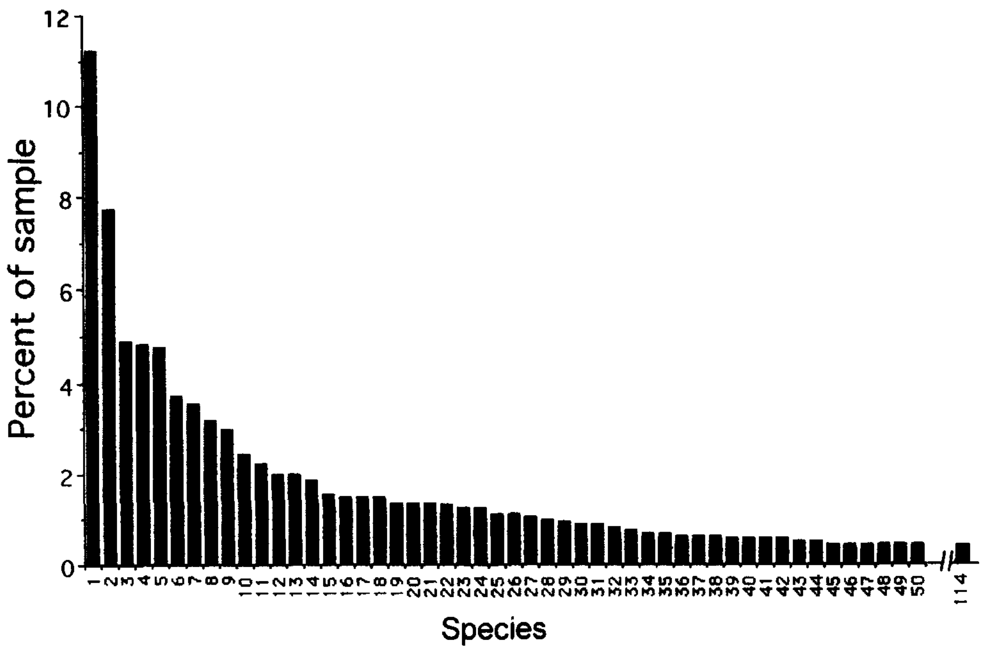

FIG. 3. Rank abundance distribution (1612 individuals, 114 species) of birds netted in *terra firme* forest in the Tapajós National Forest, Brazil. Data were combined for control blocks 1 and 3.

of all individuals captured in the two blocks (Table 1). The 10 most commonly captured species constituted only 49.3% of all individuals banded in both blocks (49.5% of individuals in C-1, 50.1% of individuals in C-3). The predominance of rare species is most evident when using Karr's (1971) definition of a rare species ($\leq$ 2% of the individuals of a sample), which indicates that 90% (104) of the 114 species in the two blocks were rare. Moreover, 20% of the 114 species were represented by only one individual.

Despite the fact that the rank-abundance distributions did not differ significantly ($P >$ 0.05) between the two control blocks, the species composition did vary significantly between the two blocks (composition x block, $P < 0.001$). Three species, *Turdus albicollis*, *Rhegmatorhina gymnops*, and *Dendrocincla merula*, significantly ($P < 0.05$) contributed to the differences in species composition between the blocks (Table 1).

Seven of 21 species with adequate sample sizes showed significant differences in captures between the two blocks. Species with significantly ($P < 0.05$) higher captures in the second growth block (C-1) than the primary forest block (C-3) included *Glyphorynchus spirurus*, *Mionectes macconnelli*, *Platyrinchus coronatus*, *Pipra rubrocapilla*, *Pipra iris*, and *Turdus albicollis*. In contrast, *Rhegmatorhina gymnops* was significantly more abundant in the primary forest block than in the secondary forest block. Two species showed significant differences in abundance between blocks that varied with season (block x season interaction). For example, *Dendrocincla merula* was more frequently ($P = 0.03$) captured in C-1 than C-3 during the dry season (27 captures vs. 19 captures) and more frequently in C-3 than C-1 during the wet season (21 vs. 11 captures). The opposite pattern was found in *Thamnomanes*

TABLE 1. Number of individuals (rank in parentheses) for the twenty-one most frequently captured species in a sample of 933 individuals in C-1, 679 individuals in C-3, and 1612 individuals in the combined sample from *terra firme* forest in the FLONA Tapajós Brazil.

Species	Guilds*	C-1	C-3	C-1 & C-3
Glyphorhynchus spirurus	S-SI-B	110 (1)	71 (1)	181 (1)
Pipra rubrocapilla	S-FR-F	86 (2)	39 (4)	125 (2)
Dendrocincla merula	S-LI-R	38 (4)	41 (2)	79 (3)
Mionectes macconnelli	S-SO-F	52 (3)	26 (7)	78 (4)
Hylophylax poecilinota	S-LI-R	37 (5)	40 (3)	77 (5)
Thamnomanes caesius	S-LI-F	34 (7)	26 (8)	60 (6)
Pipra iris	S-FR-F	37 (6)	20 (9)	57 (7)
Myrmotherula longipennis	S-SI-F	22 (9)	29 (6)	51 (8)
Rhegmatorhina gymnops	S-LI-R	14 (18)	34 (5)	48 (9)
Phlegopsis nigromaculata	S-LI-R	20 (12)	19 (10)	39 (10)
Turdus albicollis	S-SO-F	24 (8)	8 (26)	32 (12)
Platyrinchus coronatus	S-SI-A	22 (10)	10 (20)	32 (12)
Automolus infuscatus	S-LI-F	14 (17)	16 (11)	30 (13)
Conopophaga aurita	G-SI-G	11 (20)	14 (14)	25(14)
Hylophylax naevia	S-SI-F	9 (31)	15 (13)	24 (17)
Malacoptila rufa	S-LI-A	13 (19)	11 (18)	24 (17)
Myiobius barbatus	S-SI-A	14 (18)	10 (21)	24 (17)
Geotrygon montana	G-FR-G	16 (14)	6 (32)	22 (20)
Schiffornis turdinus	S-SO-F	10 (23)	12 (16)	22 (20)
Thalurania furcata	S-NI-F	15 (15)	7 (28)	22 (20)

*Classification of Karr *et al.* (1990): Foraging strata: G = Ground, S = Shrub; Diet: SI = Small insects, SO = Small insects and fruit, LI = Large insects, FR = Fruits, NI = Nectar and small insects; Substrata: A = Air, B = Branches and trunk, F = Foliage, live includes fruits and flowers, G = Ground, R = Army ants.

caesius, which was more frequently ($P = 0.02$) captured in C-3 than C-1 during the dry season (18 vs 11) in contrast to the wet season when it was captured more frequently in C-1 than C-3 (8 vs 23). Thus some species showed significant differences in abundance between the blocks, and for two species, differences in abundance between blocks depended on season.

Guild structure. Most captured birds in both blocks were insectivorous. Birds that feed primarily on insects constituted 74.6% of the species, 76.7% of the individuals, and 70.8% of the biomass of all captured birds (Table 2). Inclusion of birds that secondarily consume insects with those that primarily consume insects indicates that 83.3% of all species and 82.1% of all individuals prey on insects.

Insectivorous birds differ in the degree and nature of sociality while foraging. Especially conspicuous, are mixed species foraging flocks of insectivorous birds that included 25.4% of the species, 34.1% of the individuals, and 22.6% of the biomass in our net samples. Two common species that join mixed species flocks were among the 10 most abundant species (6th and 8th overall, Table 1), and one, *Thamnomanes caesius*, plays an important role as a nuclear species in the flocks. Birds that are obligate followers of army ants composed only a small percentage of the species captured (6.1%), but a larger percentage of individuals (11.6%) and biomass (20.3%). The

TABLE 2. Relative importance (%) of feeding guilds in combined mist net samples from blocks C-1 and C-3 in *terra firme* forest, FLONA Tapajós, Brazil.

Feeding categories	Number of species[1]	Individuals[2]	Biomass[3]
Army ant-followers	6.1	11.6	20.3
Insectivores	33.3	23.6	21.3
Insectivore/frugivores	5.3	1.4	2.5
Mixed-flock insectivores	25.4	34.1	22.6
Mixed-flock insectivore/frugivores	4.4	6.0	4.0
Subtotal/Primarily insectivores	74.6	76.7	70.8
Frugivores	7.0	13.5	11.4
Frugivore/insectivores	8.8	5.3	11.3
Subtotal/Primarily frugivores	15.8	18.8	22.7
Nectarivores	6.1	4.2	0.8
Subtotal/Nectarivores	6.1	4.2	0.8
Piscivores	0.9	0.1	0.03
Small vertebrates/insects	2.6	0.2	5.7
Subtotal Miscellaneous	3.5	0.3	5.7
	100.0	100.0	100.0

[1]Percentage of species mist-netted and assigned to feeding guilds (N = 114 species).
[2]Percentage of captured individuals per feeding guild (N = 1612).
[3]Percentage of community biomass as estimated from multiplying the number of individuals banded and mean weight per species at study site.

higher biomass representation of obligate followers of army ants is in part due to the relatively large body mass of common army ant followers such as *Dendrocincla merula* (42.4 g) and *Phlegopsis nigromaculata* (47.2 g). Obligate followers of army ants were the third, ninth, and tenth most abundantly captured species in the samples from the two blocks (Table 1).

Frugivorous species or species which fed primarily on fruit were relatively uncommon in the understory, as they represented only 15.8% of the species, 18.8% of the individuals, and 22.7% of the biomass (Table 2). Two manakin species, *Pipra rubrocapilla* and *P. iris*, were numerically the most important frugivorous species in net samples, ranking second and seventh respectively, in abundance of individuals (Table 1).

Nectarivores were rare in understory nets where they represented only 6.1% of the species, and 4.2% of the individuals. Nectarivores constituted slightly less than 1% of the biomass; this is not surprising given the small body mass of hummingbirds that compose the nectarivore guild. The rarity of nectarivorous species in the net sample is evident in the rankings by abundance curves (*Thalurania furcata*, 20th; *Phaethornis superciliosus*, 30th).

Seasonal differences in diet guild composition (G x S, df = 6, $\chi^2 = 20.82$, $P = 0.002$) were consistent in both blocks (3-way interaction, df = 3, $\chi^2 = 4.04$, $P = 0.258$). This finding was robust, as significant ($P = 0.004$) differences in dietary guild composition occurred between season when using six of the Karr diet categories for the captured birds (Fig. 4). Changes in diet guild composition are largely attributable to increased wet season

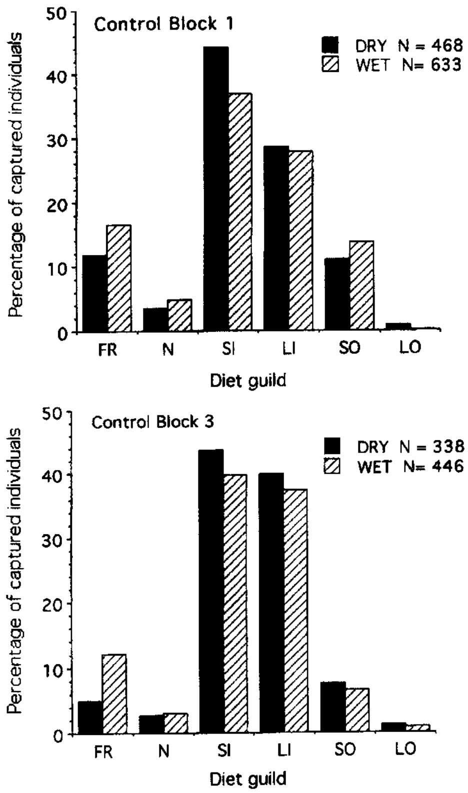

FIG. 4. Percentage of individual birds captured in different diet guilds in the dry and wet season in control blocks 1 and 3 in the Tapajós National Forest, Brazil. Diet guilds are after Karr *et al.* (1990) and include the following categories: FR, fruits or fruits and seeds; N, nectar and insects; SI, small insects, LI, large insects; SO, small insects and fruit; LI, large insects. Sample size (N) indicates the number of individuals captured in the indicated season.

captures of small omnivores (P = 0.01) and frugivores (P = 0.04) and increased dry season captures of both large (P = 0.03) and small insectivores (P = 0.01). Nectarivore captures did not change significantly between wet and dry seasons.

Slight but significant (G x B, df = 6, χ^2 = 36.36, P = 0.001) differences in guild composition were found between blocks (Fig. 4), which were seasonally consistent. Total captures of nectarivores and frugivores were significantly (P = 0.04; P = 0.01, respectively) higher in C-1 than in C-3. In addition, total captures of small insectivores was significantly higher in the secondary forest block, C-1, than in C-3.

DISCUSSION

Avian species inventory. The total list of 342 species for the FLONA Tapajós should be viewed as preliminary, given that about 42% of the listed species have inadequate documentation (e.g., no specimen, photograph, or tape recording) and require verification. In addition, habitats such as "várzea" forest, river edge and marshes, and liana forests have not been sampled adequately and more observations in the canopy are needed. Moreover, most field work has been concentrated in the eastern portion of the FLONA and surveys in the western and drier southern portions are needed. With more thorough coverage of the geographic extent and constituent habitats, we expect the list to easily reach 450 species for the entire national forest.

Given geographical ranges of Amazon bird species (Ridgely & Tudor 1989, 1994, Sick 1997), it is evident that some expected species are currently absent from our FLONA Tapajós list and are likely to be found with more extensive surveys. For example, more canopy observations in different forest types are likely to add species such as *Cotinga cotinga, Cyanerpes nitidus, Dacnis flaviventris, Hemithraupis flavicolis,* and *Euphonia chrysopasta.* Aquatic birds are mostly absent from our list and surveys along waterways will increase the numbers of species in Ardeidae as well as species in families not currently represented on the list (Podicipedidae, Anhingidae, Ciconiidae, Threskiornithidae, Anatidae, Eurypygidae, Charadriidae, and Scolopacidae). River edge and islands are expected to contribute passerines such as *Xenops tenuirostris, Sakesphorus luctuosus, Thamnophilus nigrocinereus, Myrmotherula assimilis, Myrmoborus lugubris, Elaenia pelzelni, Cephalopterus ornatus, Conirostrum speciosum, Cacicus solitarius,* and *Gymnomystax mexicanus.* We expect future surveys of "várzea" forest in the FLONA to document species such *as Pipra aureola, Schiffornis major, Heterocercus lineatus, Hypocnemoides melanopogon, Hypocnemoides maculicauda, Xiphorhynchus obsoletus, Turdus fumigatus* and *Eucometis penicillata.* Finally, we expect the list to be augmented by the addition of species characteristic of open or second growth habitats as deforestation continues along the national forest's borders.

In contrast to the total list, our confidence is higher for the documentation of the core avifauna of the *terra firme* primary forest in which most efforts were concentrated. Although about 35% of 274 species constituting the core *terra firme* avifauna had inadequate documentation (i.e., below level 2), 31 species were captured in mist nets and subsequently measured and identified in the hand. We do not expect future studies to substantially alter this total.

The core avifauna total (274 species) in the Tapajós *terra firme* primary forest is similar to species richness from *terra firme* primary forest elsewhere in Amazonia. For instance, the *terra firme* forest north of Manaus has a total of 266 core species (Cohn-Haft *et al.* 1997). An analysis of the Manu data of Terborgh and colleagues (in Karr *et al.* 1990) by Cohn-Haft *et al.* (1997) indicated a *terra firme* total of 271 species. However, Cohn-Haft *et al.* (1997) cautioned that the Manu figure might include some extremely rare or accidental species that are not part of the core total. The lowest *terra firme* total (200 species) occurs in Tambopata, Peru (Parker *et al.* 1994), but this may represent undersampling (Cohn-Haft *et al.* 1997). Thus, the results for Tapajós are consistent with a growing body of evidence indicating a remarkable consistency in avian species richness in *terra firme* forests across the breadth of the Amazon basin (Cohn-Haft *et al.* 1997). This consistency in species richness exists even though *terra firme* forests differ considerably in annual rainfall and primary productivity, suggesting that variation in avian species richness among sites may be independent of these factors in *terra firme* forest.

Understory mist net samples. Our netting results are consistent with the general patterns found in previous understory netting studies in four Neotropical continental forests (Karr *et al.* 1990), despite minor differences in analyses. Our analyses were based mostly on total numbers of individuals captured in both the wet and dry seasons, in contrast to the summaries in Karr *et al.* (1990) which are restricted to net captures in the dry season. Their comparison of net samples from La Selva (Costa Rica); Barro Colorado Island (BCI) and Soberanía National Park or Pipeline Road (Panama), Manu (Peru), and Manaus (Brazil) demonstrated high species richness, many rare species, and similarities among sites in the taxonomic identity of the most frequently captured species and trophic organization. Not surprisingly, our findings were most comparable to patterns for the Amazon sites (especially Manaus, 590 km from our site, but opposite side of the Amazon River), reflecting the close geographic proximity.

Although species accumulation curves based on the cumulative number of unique individuals rose at a faster rate than did curves based on the accumulation of captures, our results provide a similar range of values to those derived from net studies using the latter method. For instance, a sample of 600 individuals yields 80 species from combined blocks at Tapajós (90 species in C-1; 74 species in C-3) in comparison to a range of 40 to 88 species (BCI vs Manu) from samples of

600 captures (Karr *et al.* 1990). Jackknife estimates of 40 species in a sample of 100 individuals from Tapajós is similar to the jackknife estimate of 41 species from 100 captures in Manu. This latter estimate seemed low (vs 55 and 56 species in La Selva and Manaus, respectively) to Karr et al (1990) who attributed the low estimate to a high number of species with only one or two captures. This suggested a weakness of the jackknife procedure to them. Finally, a composite sample of 1000 captures from the two combined Tapajós blocks (500 captures each) yielded 96 species, compared with 76 species in Manaus, and a range of 70 to 111 species from La Selva and Manu, respectively. The high avian species richness of Tapajós net samples is comparable to samples obtained in other Neotropical forests.

A preponderance of rare species as evident in the extended tail of our rank-abundance curves from net captures is typical of avian communities of mainland tropical forests (e.g., Karr 1971, Lovejoy 1974, Pearson 1977, Wong 1986, Karr *et al.* 1990). However, rarity in net samples often represents an artifact of the sampling technique, as mist nets are not random samples of the avian community, and many species are under represented in net samples, often being common based on other sampling methods (e.g., Karr 1981, Bierregaard 1990, Remsen & Good 1996). Previous workers noted that under-representation of common species in net samples results from a variety of traits: 1) species that walk rather than fly are captured rarely, 2) very small or very large species are not captured effectively, 3) sedentary species are less likely to be captured compared to active species, and 4) species common in other habitats or strata which infrequently encounter the nets.

Net samples under-represented the abundance of at least 42 (36.8%) of the 114 species tallied in the two blocks, because of the factors contributing to sampling bias. Visual observations or detection of vocalizations indicated that these species are not rare. For example, vocal detections of antpittas and antthrushes, such as *Formicarius analis, F. colma, and Myrmothera campanisona,* indicate that such species that forage while walking are not as rare as net samples indicate. Large body size and foraging height likely contributed to the net sample rarity of *Monasa morphoeus, Crypturellus variegatus, Leptotila rufaxilla, Trogon rufus, Micrastur gilvicollis, and Celeus jumana.* At the other extreme, small species, such as hummingbirds, likely were under represented in net samples because of relatively large mesh size.

Some species are rare in net samples because they infrequently enter the forest understory, although they are more common in nearby habitats or in higher strata. This is the case for canopy or subcanopy species that infrequently descend to the understory (*Attila spadiceus, Xiphorhynchus guttatus, Lipaugus vociferans, Rhytipterna simplex, Hylophilus hypoxanthus and Tachyphonus cristatus*). Gap specialists (e.g., *Myrmeciza hemimelaena*) likely were under-represented because net lines did not adequately sample gaps. Species common in nearby early second growth (*Chiroxiphia pareola, Manacus manacus, Thryothorus leucotis, Ramphocelus carbo*) or forest edge (*Hypocnemis cantator*) only rarely passed through the forest interior understory. Finally, proximity to a stream likely accounted for the captures *of Schistocichla leucostigma, Sclateria naevia*, and *Hylophylax punctulata*, species of streamsides or "várzea" forest.

Whereas mist net samples may under-represent the abundance of some common species, net captures may also over-represent the abundance of others, particularly species that have large home ranges and actively fly through the understory (Bierregaard 1990). As others have previously suggested, actively moving foragers such as army ant followers and members of mixed species flocks will be over-represented in net samples in contrast to more sedentary sit-and-wait predators. Even though net samples are unlikely to be representative of the avian community as a whole, they likely have value for comparative purposes with other net samples from similar habitats or long-term studies.

Strong similarities between forest sites in the most frequently captured species are evident in a comparison of the 20 most common species captured in Manaus (Bierregaard 1990) and the 21 most common species (additional species due to ties) captured in FLONA Tapajós (Table 1), when the analysis is restricted to species with geographic ranges that include both sites. The Amazon River acts as a major barrier for many species (Haffer 1969, 1990), as evident in approximately a third of the species in each list that are restricted to one side of the Amazon. For example 7 of the 20 most frequently captured species in Manaus are found only north of the Amazon River (*Pithys albifrons, Gymnopithys rufigula, Thamnomanes ardesiacus, Xiphorhynchus pardalotus, Myrmotherula gutturalis, Percnostola rufifrons, Microbates collaris*) and 6 of the 21 most frequently captured species in the Tapajós are found only south of the Amazon (*Rhegmatorhina gymnops, Pipra iris, P. rubrocapilla, Myrmotherula leucophthalma, Malacoptila rufa, Phlegopsis nigromaculata*).

Of the 20 or 21 most frequently captured species at a site, approximately half the species (11) were among the most frequently captured at both Manaus and Tapajós, including *Glyphorhynchus spirurus, Hylophylax poecilinota, Mionectes macconnelli, Turdus albicollis, Dendrocincla merula, Myiobius barbatus, Myrmo-therula longipennis, Automolus infuscatus, Schiffornis turdinus, Thamnomanes caesius*, and *Geotrygon montana.* Differences in abundance between Manaus and Tapajós were suggested for shared species that were frequently captured at one site but only infrequently captured at the other site. For instance, four species on the frequently captured list for Tapajós were present, but not among the 20 frequently captured species for Manaus (*Platyrinchus coronatus, Thalurania furcata, Conopophaga aurita, Hylophylax naevia*). However, the latter two species are distributed in a patchy fashion and can be common in some net samples in Manaus (Stouffer, pers. comm.). Conversely, two species of the 20 most frequently captured species in Manaus were rare or infrequently captured in Tapajós (*Pipra pipra, Hypocnemis cantator*). Thus for species with ranges encompassing both sites, approximately 75% of the most frequently captured species also were captured commonly at both sites. Generally, species common in Manaus were common in Tapajós.

Analysis of feeding guilds based on diet classification of captured birds was consistent with previous tropical forest netting studies, in demonstrating a preponderance of insectivores, few frugivores, and even fewer nectarivores (e.g., Karr *et al.* 1990, Bierregaard 1990, Blake *et al.* 1990). Especially low numbers of frugivores and nectarivores were characteristic of the Manaus net samples, as well as those from Tapajós. Although a somewhat larger percentage of frugivorous species was captured in Manaus (27.8%) than Tapajós (15.8%), closer similarities were evident between the two sites in percentage of frugivores based on numbers of individuals (13.7% vs 18.8%) and biomass (22.3% vs 27.7%). Relative scarcity of frugivores in Manaus and Tapajós is evident in comparisons of frugivorous species in the ten most common species in samples of 1000 captures at the four forest sites studied by Karr *et al.* (1990). Frugivores represented 17.2%, 15.2%, 14.8%, and 9.1% of the species at La Selva, Pipeline Road, Manu, and Manaus, respectively, but only 8.3% at Tapajós.

Nectarivores were relatively rare in net samples and constituted similar percentages of the samples at Manaus and Tapajós in terms of the numbers of species (5.6% vs. 6.1% in the two respective sites), individuals (4.6% vs 4.2%) or biomass (0.9% vs 0.8%). In addition, both Manaus and Tapajós lacked nectarivores in the top ten most common species in 1000 capture samples, in contrast to net samples elsewhere (La Selva, 8.1%; Pipeline Road, 5.9%; Manu, 3.9%; Bierregaard 1990, Karr *et al.* 1990).

Previous studies have indicated that frugivore and nectarivore abundance is greater in second growth than primary tropical forests (e.g., Blake *et al.* 1990, Levey 1988). Captures of frugivores and nectarivores were expected to be lower in the primary forest block (C-3) relative to the block with old second growth (C-1). Our findings were mostly consistent with this, although the differences between blocks were small or absent. For instance, frugivore captures in C-3 were less than in C-1 in terms of the representation of primarily frugivorous species in net samples of species (15.0% vs 15.5% in the two respective sites), individuals (14.9% vs 21.7%) and biomass (20.3% vs 24.8%). Nectarivores constituted virtually the same levels of abundance in C-3 and C-1 for samples of species (6.3% vs. 6.8%), individuals (3.2% vs. 4.9%), and biomass (0.5% vs. 1.0%).

Our findings further support previous mist netting results indicating that the understory of mature Amazonian *terra firme* forest has low densities of frugivores and nectarivores relative to Central American forests (Bierregaard 1990). Moreover, recent mist net samples from the Ferreira Penna Research Station in the Caxiuanã National Park in the eastern Amazon (400 km west of Belém, 1°41'30"S and 51°31'45"W; Lisboa 1999) further indicate rarity of frugivores and nectarivores in the understory of *terra firme* Amazon forests. A small mist net sample (720 mist net hours, 477 individuals, 54 species) at Caxiuanã, by Melo Valente (1999) shows that frugivores constituted only 6.8% of the captures in the top ten most frequently captured species (*Turdus albicollis*, 4th; *Pipra pipra* 7th). As with net samples from Tapajós and Manaus, nectarivores were absent from the ten most frequently captured species at Caxiuanã, and the most commonly captured nectarivore, *Thalurania furcata,* ranked 15th in captures. Whether this rarity of understory necatarivores and frugivores corresponds to a paucity of food resources due to diminished understory plant productivity hypothesized for Amazon *terra firme* forests (Gentry & Emmons 1987) remains to be tested.

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APPENDIX 1. Bird check-list of Floresta Nacional do Tapajós. The sequence of non-Passeriformes families follows Sick (1997). For Passeriformes, the sequences of families and species follow Ridgely & Tudor (1989, 1994) with minor modifications as adopted by Sick (1997).

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
TINAMIDAE							
Tinamus tao	f	t	u	s	fr	g	2t
Tinamus guttatus	f	t	c	s	fr	g	2t (CM)
Crypturellus cinereus	f	t	u	s	fr	g	2t
Crypturellus soui	f, sg	t, i	c	s	fr	g	2t
Crypturellus variegatus	f	t	c	s	fr	g	2tp
Crypturellus strigulosus	sg, pl	t	u	s	fr	g	4h (CM)
Crypturellus parvirostris	pl, sg	t	u	s	fr	g	2t
ARDEIDAE							
Pilherodius pileatus	w	i	u	s	fi	w	4s
Butorides striatus	w	i	u	s	fi, ar	w	4s
CATHARTIDAE							
Sarcoramphus papa	f, sg	a	u	s, mf	ca	g	4s
Coragyps atratus	oa, pa, pl, sg	a	c	s, mf	ca	g	4s
Cathartes aura	f, sg	a	c	s, mf	ca	g	4s
Cathartes melambrotus	f, sg	a	c	s, mf	ca	g	4s
ACCIPITRIDAE							
Elanoides forficatus	f, sg	a	c	s, mf	ar	f	4s
Leptodon cayanensis	f	a	u	s	ve	a	2t (CM)
Chondrohierax uncinatus	f	a	x	s	mo	f	4s (CM)
Harpagus bidentatus	f	a	x	s	ar, ve	f	4s (CM)
Ictinia plumbea	f	a	x	s, mf	ar	f	4s (CM)
Helicolestes hamatus	w	i	x	s	mo	w	4s
Accipter bicolor	f	c	r	s	ve	a	3
Accipter superciliosus	f, sg	c	r	s	ve	a	4s (CM)
Asturina nitida	f	c	u	s	ve	g	4s
Rupornis magnirostris	sg, f, pa	c	c	s	ar, ve	g	4sh
Leucopternis albicollis	f	c	r	s	ve	f	4s
Leucopternis kuhli	f	c	u	s	ve	f	2tp

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Leucopternis schistacea	f	c	x	s	ve	f	4s (CM)
Buteotallus urubitinga	f, sg	c, a, i	u	s	ve	g	4s
Morphnus guianensis	f	c	r	s	ve	f	2tp
Harpia harpyja	f	c	r	s	ve	f	4s
Spizastur melanoleucus	f	a, c	r	s	ve	f	4s (CM)
Spizaetus ornatus	f	a, c	r	s	ve	f	2t (CM)
Spizaetus tyrannus	f	a, c	r	s	ve	f	4s (CM)
FALCONIDAE							
Herpetotheres cachinnans	sg, f	ef	u	s	ve	f	4h
Micrastur semitorquatus	f	s, m	r	s	ve	f	2t (CM)
Micrastur ruficollis	f	u	u	s	ve	f	2p
Micrastur gilvicollis	f	c	c	s	ve	f	2p
Daptrius ater	f	c	r	s, mf	ve	t	4sh (CM)
Daptrius americanus	f, sg	c	c	s, mf	om	f	2t
Milvago chimachima	sg, pa	i	u	s	ar	g	4s
Polyborus plancus	pa, sg	c, t	u	s	ca, ar	g	4s (SD)
Falco rufigularis	f	c, a	u	s	ve, ar	a	4s (SD)
CRACIDAE							
Ortalis ruficeps	f, sg	ef	c	s, mf	fr	f	4sh
Penelope superciliaris	f	t, u	u	s	fr	f	2t
Pipile cujubi	f	t, c	u	s	fr	f	2t
Mitu tuberosa	f	t, c	r	s	fr	g	4s
ODONTOPHORIDAE							
Odontophorus gujanensis	f	t	u	mf	om	g	2t
PSOPHIDAE							
Psophia viridis	f	t	u	mf	om	g	2p
RALLIDAE							
Aramides cajanea	f	t	u	s	om	g	2t
Laterallus viridis	sg	t	c	s	om	g	2t
Porphyrula martinica	w	i	c	s	om	f	4s

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
HELIORNITHIDAE							
Heliornis fulica	w	i	u	s	ar	w	4s
JACANIDAE							
Jacana jacana	w	i	u	s	ar	f	4s
COLUMBIDAE							
Columba subvinacea	f	c, m	c	s	fr	f	4h
Columba plumbea	f	c, m	c	s	fr	f	2t
Columbina passerina	pl, oa, sg	t	c	mf	se	g, f	4s
Columbina talpacoti	pl, oa, sg	t	c	mf	se	g, f	4s
Leptotila verreauxi	pl, sg	t, ef	u	s	fr	g	4s (CM)
Leptotila rufaxilla	f	t, ef	u	s	fr	g	3
Geotrygon montana	f, sg	t	c	s	fr	g	1
PSITTACIDAE							
Ara macao	f, c	c	c	mf, s	fr	f	2t
Ara chloroptera	f	c	x	s	fr	f	4s
Ara severa	f	c	c	mf	fr	f	2p
Aratinga leucophthalmus	f, sg, pl, oa	c	c	mf	fr	f	2t
Pyrrhura picta	f, sg, oa	c	c	mf	fr	f	2t
Brototeris chrysopterus	f, sg, oa	c	c	mf	fr	f	2t
Pionites leucogaster	f	c	c	s, mf	fr	f	2t
Pionopsitta vulturina	f	c	u	mf	fr	f	2t
Pionus menstruus	f, sg, pl	c	c	mf, s	fr	f	2t
Pionus fuscus	f, sg, pl	c	c	mf, s	fr	f	2t
Amazona ochrocephala	f, sg, oa	c	c	mf, s	fr	f	2t
Amazona amazonica	f, sg, oa	c	c	mf, s	fr	f	2t
Amazona farinosa	f, sg	c	c	mf, s	fr	f	2t
Deroptyus accipitrinus	f	c	c	mf, s	fr	f	2t
CUCULIDAE							
Piaya cayana	sg, f	c	c	s, uf	ar	f	2t
Piaya melanogaster	f	c	u	s	ar	f	2t

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Crothophaga ani	pl, sg, oa	t	c	mf	ar	g	4s
Tapera naevia	sg, pl, oa	t	u	s	ar	g, f	2t
TYTONIDAE							
Tyto alba	sg	ef	u	s	ca	g	4h
STRIGIDAE							
Otus choliba	sg	m, ef	c	s	ar	f	2t
Otus watsonii	f	m	c	s	ar	f	1
Lophostrix cristata	f	m	c	s	ar	f	4sh (CM)
Pulsatrix perspicillata	f	c, m	u	s	ve	f	2t
Glaucidium hardyi	f	c	c	s	ar	f	2t
NYCTIBIIDAE							
Nyctibius grandis	f, pa	c	u	s	ar	a	4sh
Nyctibius griseus	f, sg	ef	c	s	ar	a	2t
Nyctibius leucopterus	f	c	c	s	ar	a	2t
CAPRIMULGIDAE							
Lurocalis semitorquatus	f	a	u	s	ar	a	2t
Podager nacunda	oa, pa	a	u	s	ar	a	4s
Nyctidromus albicollis	sg	ef	c	s	ar	a	2t
Nyctiphrynus ocellatus	f	ef	u	s	ar	a	1
Caprimulgus nigrescens	f	ef	c	s	ar	a	3
APODIDAE							
Chaetura spinicauda	sg, f	a, ef	c	mf	ar	a	4s
Chaetura brachyura	sg, f	a, ef	c	mf	ar	a	4s
Panyptila cayennensis	sg, f	a	x	s	ar	a	4s
Reinarda squamata	sg, f	a, i	c	mf	ar	a	4s
THROCHILIDAE							
Glaucis hirsuta	f, sg	u, ef	c	s	ni	f	1
Threnetes leucurus	f	u	r	s	ni	f	3
Phaethornis superciliosus	f, sg	u, ef	c	s, l	ni	f	3
Phaethornis bourcieri	f	u	c	s, l	ni	f	1

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Phaethornis longuemareus	f	u	c	s	ni	f	1
Campylopterus largipennis	f	c, ef	c	s	ni	f	2p
Florisuga mellivora	f	c	u	s	ni	f	1
Anthracothorax nigricollis	oa	c	c	s	ni	f	4s
Avocettula recurvirostris	f	c	r	s	ni	f	2t (CM)
Thalurania furcata	f, sg	tf	c	s	ni	f	1
Hylocharis sapphirina	f	ef	u	s	ni	f	4s (CM)
Topaza pella	w	ef, i	u	s, l	ni	f	4s
Heliothryx aurita	f	c	u	s	ni	f	3
Heliomaster longirostris	f	ef	u	s	ni	f	4s (CM)
TROGONIDAE							
Trogon melanurus	f	m	c	s, cf	om	f	2t
Trogon viridis	f	m	c	s	om	f	2t
Trogon rufus	f	m	c	s, uf	om	f	1
Trogon violaceus	f	m, ef	c	s	om	f	2t
ALCEDINIDAE							
Ceryle torquata	w	i	x	s	fi	w	4s
Chloroceryle amazona	w	i	r	s	fi	w	4s
Chloroceryle americana	w	i	r	s	fi	w	4s
Chloroceryle aenea	f	i, ef	r	s	fi	w	3
MOMOTIDAE							
Baryphthengus martii	f	m	r	s	om	f	3
Momotus momota	f, sg	m	u	s	om	f	3
GALBULIDAE							
Brachytalba lugubris	f	c, ef	r	s	ar	a	4s
Galbula cyanicollis	f	m	c	s	ar	a	1
Galbula dea	f	c, ef	u	s	ar	a	3
Jacamerops aurea	f	m	u	s	ar	f	2t
BUCONNIDAE							
Notharchus macrorhynchus	f	c	u	s	ar	f	2t

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Notharchus tectus	f, sg	c, i	u	s	ar	f	4s
Bucco tamatia	f, sg	m, ef	u	s	ar	f	4s
Bucco capensis	f	m	u	s	ar	f	3
Nystalus maculatus	sg	u	u	s	ar	f	4s
Malacoptila rufa	f	s, m	c	s	ar	f	1
Monasa morphoeus	f	m	c	mf	ar	a	2p
Chelidoptera tenebrosa	pa, oa,	ef, a	u	s	ar	a	4s
RAMPHASTIDAE							
Pteroglossus aracari	f, sg	c	c	mf	om	f	2t
Pteroglossus inscriptus	f	c	u	mf	om	f	4s
Pteroglossus bitorquatus	f	c	r	mf	om	f	4s
Selenidera gouldii	f	c	u	mf	om	f	2t
Ramphastos vitellinus	f, sg	c	c	s	om	f	2t
Ramphatos tucanus	f, sg	c	c	s	om	f	2t
PICIDAE							
Picumnus aurifrons	f, sg	c, ef	u	mf	ar	b	1
Piculus flavigula	f	m	c	s, uf	ar	b	2t
Celeus jumana	f	m	c	s	om	b	3
Celeus grammicus	f	m	c	s	om	b	4s (CM)
Celeus flavus	f, sg	m	u	s	om	b	2t (CM)
Celeus torquatus	f	c, m	c	s	om	b	2t
Dryocopus lineatus	f, sg	ef	c	s	om	b	2t
Melanerpes cruentatus	sg, oa	c, ef, i	c	mf	om	b	2t
Veniliornis affinis	f, sg	m, u	c	s, uf	ar	b	3
Campephilus rubricollis	f	c, m	c	s	om	b	2t
FURNARIIDAE							
Synallaxis gujanensis	sg	ef	u	s	ar	f	2t
Synallaxis rutilans	f	u	u	s, uf	ar	f	4s (CM)
Xenops minutus	f, sg	u, m	c	s, uf	ar	b	1
Xenops milleri	f	c	u	s, cf	ar	b	4s (CM)

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Philydor erythrocercus	f	u	u	s, uf	ar	d	3
Philydor ruficaudatus	f	u	u	s, uf	ar	d	3
Philydor pyrrhodes	f	u	u	s, uf	ar	d	3
Automolus infuscatus	f, sg	u	c	s, uf	ar	d	1
Automolus ochrolaemus	f, sg	u	u	s, uf	ar	d	2p
Automolus rufipileatus	f	u	u	s,	ar	d	1
Sclerurus mexicanus	f	t	u	s	ar	g	1
Sclerurus rufigularis	f	t	u	s	ar	g	1
Sclerurus caudacutus	f	t	u	s	ar	g	2p
DENDROCOLAPTIDAE							
Dendrocincla fuliginosa	f, sg	u, m	c	s, uf, af	ar	an	1
Dendrocincla merula	f	u	c	af, s	ar	an	1
Deconychura longicauda	f	u,m	u	uf, s	ar	b	1
Deconychura stictolaema	f	u	u	uf, s	ar	b	1
Glyphorynchus spirurus	f, sg	u, m	c	s, uf	ar	b	1
Sittasomus griseicapillus	f	u	u	uf	ar	b	4h (CM)
Hylexetastes uniformis	f	m	u	s, af	ar	b	1
Dendrocolaptes certhia	f	m	u	s, af	ar	b, an	1
Dendrocolaptes picumnus	f	m	u	s, af	ar	an	1
Xiphocolaptes promeropirhynchus	f	m	r	s	ar	b	3
Xiphorhynchus picus	sg, oa	m, ef	c	s, uf	ar	b	2t
Xiphorhynchus spixii	f	u, m	c	s, uf	ar	b	1
Xiphorhynchus guttatus	f	c, m	c	s, uf	ar	b	2tp
Lepidocolaptes albolineatus	f	c	c	s, cf	ar	b	4s
Campylorhamphus procurvoides	f	c, m	u	s, uf	ar	b	2p
THAMNOPHILIDAE							
Cymbilaimus lineatus	f, sg	u, m, ef	u	s, uf	ar	f	2tp
Taraba major	sg, f	ef	c	s	ar	f	2t
Thamnophilus aethiops	f	u	c	s, uf	ar	f	1
Thamnophilus schistaceus	f, sg	u	c	s, uf	ar	f	1

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Pygiptila stellaris	f	u	c	s	ar	f	3
Thamnomanes caesius	f, sg	u	c	s, uf	ar	f	1
Herpsilochmus rufimarginatus	f	c, m	u	s	ar	f	2t
Microrhopias quixensis	f, sg	m, u	u	s, uf	ar	f	1
Myrmotherula brachyura	f	u	c	s, cf	ar	f	2t
Myrmotherula sclateri	f	u	c	s, cf	ar	f	2t
Myrmotherula hauxwelli	f	u, m	u	s, uf	ar	f	1
Myrmotherula leucophthalma	f, sg	u, m	c	s, uf	ar	f	1
Myrmotherula ornata	f	m, u	u	s, uf	ar	f	1
Myrmotherula axillaris	f, sg	u, tf, ef	u	s, uf	ar	f	1
Myrmotherula lontipennis	f, sg	u	c	s, uf	ar	f	1
Myrmotherula menetriesii	f	u, m	c	s, uf	ar	f	1
Cercomacra cinerascens	f	c, m	c	s	ar	f	1
Cercomacra nigrescens	f, sg	tf, ef, m	u	s	ar	f	1
Pyriglena leuconota	f	u	u	af, s	ar	an	2tp
Myrmoborus myotherinus	f	u	c	s	ar	f	1
Dichrozona cincta	f	t	u	s	ar	g	1
Hylophylax naevia	f	u	c	s	ar	f	1
Hylophylax punctulata	f	u, i	u	s	ar	f	2tp
Hylophylax poecilinota	f	u	c	s, af	ar	f, an	1
Hypocnemis cantator	f, sg	u, ef, tf	c	s	ar	f	1
Hypocnemis hypoxantha	f	m, ef	u	s	ar	f	2t (CM)
Sclateria naevia	f	i, u	c	s	ar	g	2t
Schistocichla leucostigma	f	tf, i	u	s	ar	f	3
Myrmeciza hemimelaena	f, sg	u, tf, ef	c	s	ar	f	1
Myrmornis torquata	f	t	u	s	ar	g	1
Rhegmatorhina gymnops	f	u,t	c	s, af	ar	an	1
Phlegopsis nigromaculata	f	u,t	c	s, af	ar	an	1
FORMICARIIDAE							
Formicarius analis	f, sg	t	u	s	ar	g	1

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Formicarius colma	f	t	u	s	ar	g	1
Grallaria varia	f	t	r	s	ar	g	4s
Myrmothera campanisona	f	t, tf	u	s	ar	g	2tp
Hylopezus macularius	f	t	u	s	ar	g	2t
Hylopezus berlepschi	sg	t, ef	u	s	ar	g	2t
CONOPOPHAGIDAE							
Conopophaga aurita	f	u, t	c	s	ar	g	1
TYRANNIDAE							
Elaenia flavogaster	ao, sg	c	c	s	ar	a	2t
Myiopagis gaimardii	f, sg	ef, c, m	c	s, cf	ar	f	2t
Camptostoma obsoletum	oa	c	c	s	ar	f	2t
Tyrannulus elatus	f, sg	c, ef	c	s, cf	ar	f	2t
Ornithion inerme	f	c, ef	c	s, cf	ar	f	2t
Zimmerius gracilipes	f	c	c	s, cf	om	f	2t (CM)
Mionectes oleagineus	f, sg	u	u	s	om	f	3
Mionectes macconnelli	f, sg	u	c	s, l	om	f	1
Myiornis ecaudatus	f	m, ef	c	s	ar	f	2t
Lophotriccus galeatus	f	m	c	s	ar	f	1
Hemitriccus striaticollis	sg	m	c	s	ar	f	4s (CM)
Hemitriccus minimus	f	m	r	s	ar	f	2t (CM)
Corythopis torquata	f	u, t	u	s	ar	f	3
Platyrinchus platyrhynchos	f	u, m	c	s, l	ar	f	1
Platyrinchus saturatus	f	m, u	u	s	ar	a, f	1
Platyrinchus coronatus	f	u	c	s	ar	a	2tp
Tolmomyias sulphurescens	f	m, c	u	s	ar	f	3
Tolmomyias poliocephalus	sg, f	c, ef	c	s, cf	ar	f	2t (CM)
Tolmomyias assimilis	f	c	c	s, cf	ar	f	4s (CM)
Rhynchocyclus olivaceus	f	m	u	s, uf	ar	f	3
Ramphotrigon ruficauda	f	m	u	s	ar	f	3
Onychorhynchus coronatus	f	u	u	s, uf	ar	a	1

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Myiobius barbatus	f	u	u	s, uf	ar	a	1
Terenotriccus erythrurus	f	m, u	u	s, uf	ar	a	1
Contopus nigrescens	f	c, ef	xm?	s	ar	a	2t (CM)
Contopus borealis	sg, f	c, ef	xb	s	ar	a	4s (CM)
Colonia colonus	f, sg	c	xa	s	ar	a	4s
Attila cinnamomeus	sg	i	u	s	ar	a	2t
Attila spadiceus	f	c, m	c	s	ar	f	1
Rhytipterna simplex	f	m	c	s	ar	f	2t
Myiarchus ferox	oa, sg	ef	c	s	om	a, f	4s (CM)
Myiarchus tuberculifer	sg, f	u	u	s	ar	a, f	4sh (CM)
Megarhynchus pitangua	oa, sg	ef	c	s	om	a, f	4sh
Pitangus sulphuratus	oa, pa, sg	i, ef	c	s	om	a, f	4sh
Philohydor lictor	w, sg, pl	i	c	s	om	a, f	2t
Myiozetetes cayanensis	sg, f, oa	c, ef, i	c	s	om	a, f	2t
Myiozetetes luteiventris	f, sg	tf, ef	u	s	om	a, f	2t
Conopias trivirtata	f	c	c	s	om	f	4sh (CM)
Myiodinastes maculatus	oa, sg, f	c, ef	ca?	s	om	f	4sh (CM)
Legatus leucophaius	oa, sg, f	c, ef	c	s	fr	f	2t
Empidonomus varius	sg, oa	c, ef	ca?	s	om	f	4s
Tyrannus melancholicus	oa, sg	c, ef, i	c	s	om	a	2t
Pachyramphus marginatus	f	m	u	s	ar	f	3
Pachyramphus rufus	sg, oa	ef	u	s	om	f	4s
Pachyramphus minor	f	c, m	u	s	ar	f	2t (CM)
Tityra inquisitor	f	c	u	s	om	f	4sh (CM)
Tityra cayana	f	c	u	s	om	f	4s
Tityra semifasciata	f	c	u	s	om	f	2t
PIPRIDAE							
Schiffornis turdinus	f	u	c	s	ar	f	1
Tyranneutes stolzmanni	f	m	c	s	om	f	1

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Piprites chloris	f	c, m	u	s, bc	ar	f	1
Chiroxiphia pareola	f, sg	u, m	u	s, l	fr	f	3
Manacus manacus	f, c	u	u	s, l	fr	f	3
Pipra iris	f, sg	tf, ef	c	s, l	fr	f	1
Pipra pipra	f	m	r	s, l	fr	f	1
Pipra rubrocapilla	f	u, m	c	s, l	fr	f	1
COTINGIDAE							
Iodopleura isabellae	f	c, ef	x	s	fr	f	4s (CM)
Cotinga cayana	f	c	r	s	fr	f	4s
Xipholena lamellipennis	f	c	r	s	fr	f	4s
Laniocera hypopyrra	f	m	r	s	om	f	2p
Lipaugus vociferans	f	m	c	s, l	om	f	2t
Querula purpurata	f	c, ef	c	mf	om	f	2t
Phoenicircus carnifex	f	c, m	u	s, l	fr	f	1
HIRUNDINIDAE							
Progne chalybea	sg, oa	a, i	u	mf	ar	a	4s
Tachycineta albiventer	w	a, i	u	mf	ar	a	4s
Atticora fasciata	w	a, i	u	mf	ar	a	4s
Stelgidopteryx ruficollis	sg, oa	a	u	mf	ar	a	4s
TROGLODYTIDAE							
Campylorhynchus turdinus	f, oa	c	u	s	ar	f	2t
Thryothorus coraya	f, sg	ef	c	s, uf	ar	f	1
Thryothorus leucotis	sg	u, ef, i	c	s	ar	f	2t
Odontorchilus cinereus	f	c	c	cf	ar	f	4s
Troglodytes aedon	oa, sg	u	c	s	ar	f	2t
Cyphorhinus aradus	f	t, u	c	s	ar	g	1
Microcerculus marginatus	f	t, u	c	s	ar	g	1
SYLVIIDAE							
Ramphocaenus melanurus	f	m, u	c	s, uf	ar	f	2tp

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Polioptila guianensis	f	c, ef	u	cf	ar	f	4s (CM)
TURDIDAE							
Catharus fuscescens	f	u	xb	s	om	f	1
Turdus albicollis	f	u, m	c	s	om	f	1
VIREONIDAE							
Cyclarhis gujanensis	f, sg, oa	c, ef	u	s	ar	f	2t
Vireolanius leucotis	f	c, m	c	s, cf	ar	f	2t
Vireo olivaceus	sg, f	c, ef	c	s, cf	ar	f	2t
Hylophilus semicinereus	f, oa	c, m, ef	u	s, cf	ar	f	2t
Hylophilus hypoxanthus	f	c	c	s, cf	ar	f	2t
Hylophilus ochraceiceps	f	m, u, tf	c	s, uf	ar	f	1
EMBERIZIDAE							
PARULINAE							
Granatellus pelzelni	f	m, c	u	s, uf, cf	om	f	3
Basileuterus rivularis	f, c	m, i	c	s, bc	ar	f	1
COEREBINAE							
Coereba flaveola	oa, sg, f	c, ef	c	s	ni	f	1
THRAUPINAE							
Lamprospiza melanoleuca	f	c	c	s, mf, cf	om	f	2t
Hemithraupis guira	f	c	u	s, cf	om	f	4s (CM)
Lanio versicolor	f	c, m	u	s, cf	ar	f	1
Tachyphonus cristatus	f	c, m	u	s, cf	om	f	4s
Tachyphonus surinamus	f	m	u	s, cf	om	f	3
Tachyphonus luctuosus	sg, f	m, ef	u	s	om	f	1
Tachyphonus rufus	sg, pl, pa	c	u	s	om	f	2t (CM)
Habia rubica	f, sg	u, ef	c	mf, uf	om	f	1
Ramphocelus carbo	sg, pl, pa, oa	ef	c	s, mf	om	f	3
Thraupis episcopus	sg, pl, pa, oa, f	c, ef	c	s, mf	om	f	4s
Thraupis palmarum	sg, pl, pa, oa, f	c, ef	c	s, mf	om	f	4s

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Euphonia violacea	f, sg,oa	c, ef	c	s, cf, mf	fr	f	2t
Euphonia minuta	f	c	u	cf	fr	f	4s (CM)
Euphonia rufiventris	f	c	u	s, cf	fr	f	4s (CM)
Tangara mexicana	f, sg, oa	c, ef	c	mf, cf	fr	f	4s
Tangara punctata	f	c, ef	u	cf	fr	f	4s
Tangara velia	f	c	u	s, cf	om	f	4sh (CM)
Dacnis lineata	f, sg	c, ef	u	cf	om	f	4sh (CM)
Dacnis cayana	sg, f	ef	u	cf	om	f	4sh (CM)
Chlorophanes spiza	f	c	u	cf	om	f	2t (CM)
Cyanerpes caeruleus	f	c	u	s, cf	om	f	3
Cyanerpes cyaneus	f	c	u	s, cf	om	f	4s
EMBERIZINAE							
Volatinia jacarina	pl oa, sg	t	c	mf	se	f	4s
Sporophila nigricollis	pl, oa, sg	t	x	mf	se	f	4s
Sporophila caerulescens	pl, oa, sg	t	c	bm	se	f	4s
Oryzoborus angolensis	pl, oa, sg	t, u, ef	u	s	se	f	3
Arremon taciturnus	f, sg	u, ef	c	s	om	g	1
Paroaria gularis	w	i	u	s, mf	om	f	4s
CARDINALINAE							
Caryothraustes humeralis	f	c, ef	u	cf	om	f	4s (CM)
Periporphyrus erythromelas	f	m	r	s, mf	om	f	3
Pitylus grossus	f	m	c	s, mf, cf	om	f	2t
Saltator maximus	f, sg, oa	m	c	s	om	f	4s
Cyanocompsa cyanoides	f, sg	u	c	s	om	f	2t
ICTERINAE							
Psarocolius decumanus	f	c	u	mf	om	f	2t (CM)
Psarocolius viridis	f	c	c	mf	om	f	2t (CM)
Psarocolius bifasciatus	f	c	u	mf	om	f	4s
Cacicus cela	f, oa, sg	c, m	c	mf	om	f	2t

APPENDIX 1. Continuation.

Families and species	Habitat[a]	Microhabitat[b]	Abundance[c]	Sociality[d]	Diet[e]	Substrate[f]	Evidence[g]
Cacicus haemorrhous	f	c	u	mf	om	f	2t
Icterus cayanensis	f, oa	c	u	mf	om	f	2t
Scaphidura oryzivora	f, oa, sg	c	u	mf	om	f	4s
Molothrus bonariensis	ua, pa	u	u	mf	om	f	4s

[a]Habitat (if more than one listed, ordered in decreasing preference): f = *terra firme* forest, sg = recent or old secondary growth including the edge of the Santarém-Cuiabá Road, pl = small plantations of rice, corn or manioc, w = near a small stream in open areas, pa = pasture, oa = open areas near houses with fruit trees such as mangos (*Mangifera indica*).

[b]Microhabitat: t = terrestrial, u = understory, m = midstory, c = canopy, a = aerial, i = water surface or edge, ef = edge forest, tf = treefall.

[c]Abundance (in preferred habitat): r = rare, u = uncommon, c = common, x = casual, followed by seasonality code (if not year-round resident): a = austral migrant, b = boreal migrant, m = unspecified movements.

[d]Sociality: s = solitary or in pairs, mf = monospecific flocks, uf = understory heterospecific flocks, cf = canopy heterospecific flocks, af = army ant flocks, l = leks.

[e]Diet: fr = fruits, ar = arthropods, ca = carrion, ve = vertebrates, fi = fish, se = seeds, om = fruits, seeds and arthropods, mo = mollusks, ni = nectar.

[f]Substrate: g = ground, f = live foliage, d = dead foliage, a = air, w = water, b = bark, aa = army ant.

[g]Evidence: 1 = specimen collected, 2t = tape-recorded, 2tp = tape recorded & photographed, 2p = photographed, 3 = captured in net, 4s = sight record, 4sh = sight record & heard, 4h = heard. Documented by other observers including Sidnei de Melo Dantas (SD), and Curtis Marantz (CM).