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# SPECIES COMPOSITION OF BIRD COMMUNITIES IN SHADE COFFEE PLANTATIONS IN THE VENEZUELAN ANDES

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**Resumen. – Avifauna de cafetales de sombra en los Andes de Venezuela. –** Estudiamos la avifauna y las características del hábitat de cafetales de sombra en los Andes venezolanos. Encontramos marcadas diferencias en la composición de especies entre las plantaciones de ambas vertientes de la Cordillera de Mérida. Los cafetales de la vertiente occidental tuvieron una riqueza de especies mayor que aquellos de la vertiente oriental. La frecuencia con la cual las aves usaron el estrato del café varió notoriamente entre los sitios de estudio, lo cual puede reflejar las diferencias en la estructura del paisaje que rodea a los cafetales. Algunos árboles del dosel son elementos importantes del hábitat tanto para las especies residentes como para las migratorias invernales. Dos tercios de las especies registradas durante nuestro estudio fueron observadas usando *Erythrina poeppigiana*, de las cuales cerca de la mitad fueron observadas explorando activamente y probando flores abiertas. Los resultados de este estudio sugieren que los cafetales de sombra en Venezuela pueden ser un hábitat favorable para especies residentes y migratorias invernales. La calidad del hábitat puede incrementarse por la presencia de especies de árboles tales como *Erythrina poeppigiana* en el dosel y la presencia de arbustales dispersos en el estrato del café.

**Abstract. –** We studied the avifauna and habitat characteristics of shade coffee plantations in the Venezuelan Andes. We uncovered striking differences in the assemblage composition of plantations on opposite sides of the Venezuelan Andes. Plantations on the western slope had higher species richness than those on the eastern slope. Our study sites differed greatly in the frequency with which birds were observed to use the coffee layer, which may reflect differences in the landscape structure surrounding the plantations. Certain canopy tree species are important habitat features for both resident and migrant species. Two-thirds of the species detected during our surveys were observed using *Erythrina poeppigiana*; over half of these species were observed actively investigating and probing open flowers. The results of this study suggest that shade coffee plantations in Venezuela may offer suitable habitat for both residents and wintering Neotropical migrants. This suitability may be increased by the presence of trees such as *Erythrina poeppigiana* in the canopy and shrub interspersion in the coffee layer. *Accepted 26 April 2002.*

**Key words**: Andes, avian assemblage, *Erythrina poeppigiana*, foraging behavior, Neotropical migrants, plantation management, shade coffee, species richness, Venezuela.

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## INTRODUCTION

Habitat destruction in the tropics in the late twentieth century was characterized by high rates of conversion of natural landscapes to agricultural landscapes (Hartshorn 1992, Stotz *et al.* 1996). This rapid conversion and its consequences for tropical biological diversity have led to an increase in interest in the role of agroecosystems and other managed landscapes in preserving natural populations and diversity (Pimentel *et al.* 1992, Thiollay 1995, Daily *et al.* 2001, Reitsma *et al.* 2001). In the Neotropics, research has focused on the effects of coffee production on biodiversity both as a consequence of its prevalence and economic importance (Greenberg *et al.* 1997a). This research contributed to the notion that traditional methods of growing coffee in shade plantations in the Neotropics are compatible with maintaining high levels of biological diversity (Moguel & Toledo 1999). Although the biodiversity of many different taxa has been studied in shade coffee plantations (Perfecto *et al.* 1996, Moguel & Toledo 1999, Roberts *et al.* 2000, Perfecto & Vandermeer 2002), most research has focused on avian diversity (Griscom 1932, Wunderle & Latta 1996, 1998, Greenberg *et al.* 1997a, 1997b; Wunderle 1999, Jones *et al.* 2000).

Shade coffee production comprises a variety of management practices, ranging from growing coffee under natural or slightly modified forest cover to the maintenance of a highly specialized monotypic shade canopy (Moguel & Toledo 1999). Each of these management regimes possesses different potential for maintaining avian species diversity (Greenberg *et al.* 1997a). This potential can be affected by additional management techniques, such as the removal of epiphytic growth from the canopy and midstory branches of the shade layer (Greenberg *et al.* 1997a, Johnson 2000).

In this paper, we describe the avian community of Venezuelan shade-coffee plantations on both the western and eastern slope of the Venezuelan Andes. This research represents one of the first, if not the only, studies on shade coffee plantations in South America and the first to document the use of Venezuelan shade coffee plantations by local resident and Neotropical migrant bird species. We also present a preliminary examination of plantation habitat characteristics and discuss the potential effects of plantation management on avian species richness.

## METHODS

This study was undertaken in the states of Mérida and Barinas, Venezuela. These two states, and the adjacent states of Tachira, Trujillo, and Lara, contain the most northerly stretch of the contiguous Andes in South America. Two study sites were located on the eastern (Altamira: 8°49'N, 70°31' W) and western (Cucuchica: 8°20'N, 71°44'W) slopes of the eastern spine of the Venezuelan Andes (Fig. 1). Four coffee plantations (herein referred to as cafetales) were surveyed on the eastern slope and three cafetales were surveyed on the western slope (Table 1). The four eastern cafetales (A1–4) were separated by an average distance of 800 m; the three western cafetales (C1–3) were separated by an average of 500 m. The average size of the cafetales was 4.2 ± 0.3 ha (mean ± 1 SE). All the cafetales were between 20 and 40 years old. Tree species commonly found in the canopy of the seven cafetales included *Inga vera*, *Erythrina poeppigiana*, *Cedrela mexicana*, *Heliocarpus popayanensis* and *Persea americana*.

Avian species assemblages of the seven cafetales were assessed between 15 January and 15 March 1997. We established one 400 m transect in each of the cafetales. The routes were walked slowly between sunrise and 4 h post-sunrise and all species detected within 25

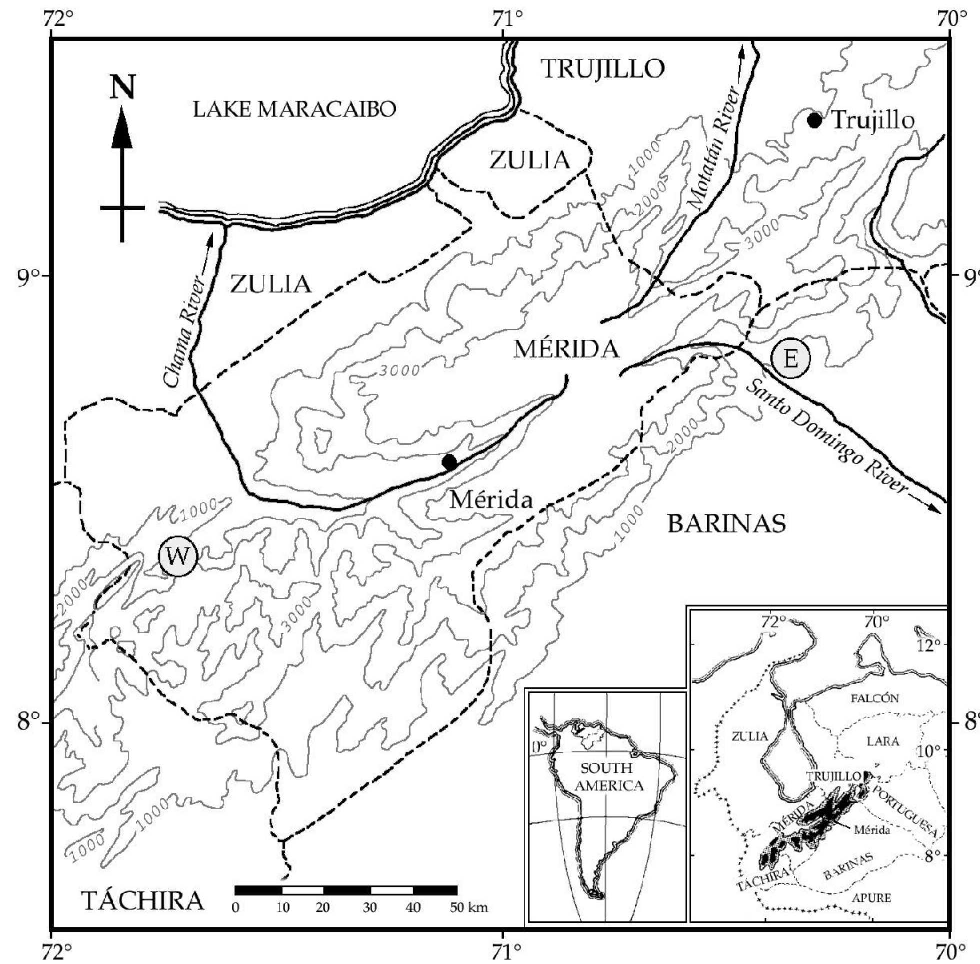


FIG. 1. Map of Venezuelan Andes denoting location of Altamira (E) and Cucuchica (W) study sites.

m on either side the transect line (either visually or aurally) were noted. The location of each individual within the foliage profile was noted, as was any behavior (e.g., foraging in coffee, singing from emergent tree). Each survey lasted approximately 1 h. A single observer performed all observations (JJ). Each eastern cafetal was surveyed 4 times, while the three western cafetales were surveyed 3–5 times each. If mixed-species flocks were encountered during the survey, extra time was taken to assess flock species composition (for details on flock composition, see Jones *et al.* 2000). Extra time was also taken to record species visiting flowering canopy trees (e.g., *Erythrina poeppigiana*). Species not observed during the surveys but observed during the course of other work are listed in Appendix 1. For species richness, we present the total number of species recorded on transects for a given cafetal. To examine the potential effect of differences in sampling

TABLE 1. Habitat and site characteristics for shade coffee plantations on the eastern and western slopes of the Venezuelan Andes. Values presented for habitat variables are mean ± SE for untransformed variables. Seven habitat plots were established each of the Altamira sites (A1–4), 8 in Cucuchica 1 (C1), and 9 in Cucuchica 2–3.

| | A1 | A2 | A3 | A4 | C1 | C2 | C3 |
|---|---|---|---|---|---|---|---|
| Size (ha) | 4.0 | 4.3 | 5.2 | 4.9 | 3.3 | 3.4 | 4.2 |
| Elevation (m) | 850–875 | 780–825 | 625–675 | 675–720 | 700 | 725 | 725–775 |
| % non-coffee | 5.7 ± 5.7 | 24.3 ± 7.0 | 17.1 ± 6.9 | 10.7 ± 6.7 | 16.3 ± 9.2 | 3.8 ± 1.1 | 38.3 ± 10.3 |
| % mid cover (6-12 m) | 24.3 ± 7.8 | 11.2 ± 4.0 | 16.4 ± 7.5 | 14.3 ± 3.0 | 12.5 ± 4.2 | 28.9 ± 9.7 | 33.3 ± 7.7 |
| % mid cover (12-18 m) | 30.0 ± 9.0 | 9.3 ± 3.5 | 16.4 ± 6.3 | 12.9 ± 2.1 | 13.8 ± 5.4 | 22.8 ± 7.9 | 23.3 ± 5.4 |
| % canopy cover (>18 m) | 32.9 ± 5.2 | 42.9 ± 7.1 | 42.9 ± 9.7 | 56.4 ± 6.4 | 66.3 ± 4.8 | 47.2 ± 8.9 | 52.2 ± 5.4 |
| Avg. canopy height (m) | 23.6 ± 0.9 | 22.1 ± 1.0 | 23.6 ± 0.9 | 23.6 ± 0.9 | 27.1 ± 1.5 | 21.1 ± 3.1 | 26.7 ± 1.7 |
| % Inga in canopy | 54.3 ± 9.5 | 32.1 ± 9.0 | 65.0 ± 10.2 | 57.1 ± 8.1 | 42.5 ± 11.3 | 71.7 ± 9.2 | 7.2 ± 2.2 |
| % Epiphyte cover | 23.4 ± 6.5 | 51.4 ± 8.3 | 52.9 ± 7.5 | 25.7 ± 4.3 | 10.0 ± 5.0 | 22.2 ± 3.6 | 67.8 ± 3.6 |
| % Forest connection | 70 | 65 | 40 | 35 | 10 | 45 | 75 |

effort, we conducted a rarefaction analysis (Simberloff 1978, James & Rathburn 1981). In this analysis, we compared the expected number of species with a sample of 200 individuals. The similarities between cafetal species assemblages were assessed using cluster analysis on a presence-absence matrix (Ward's Hierarchical method; Sokal & Rohlf 1995). Only those species detected in the first three surveys of each cafetal are included in the similarity assessment.

We measured six habitat characteristics in each cafetal (Table 1). All habitat measurements were made within randomly located 5-m radius plots. We established 28 habitat plots in the four eastern cafetales and 26 plots in the three western cafetales. The percentage of non-coffee in the understory was estimated as the percent cover of non-coffee vegetation within the circle. Midstory and canopy cover measurements were taken by visually projecting a 1-m radius cylinder, centered in the 5-m radius plot, from the ground to the canopy and estimating the cover of branches intersecting the cylinder for each of the following height intervals: midstory (6–12 m and 12–18 m) and canopy (everything above 18 m). A single observer made all cover estimates (JJ). Canopy height was estimated using a clinometer and measuring tape.

The cafetales were subjected to a variety of management techniques. One technique was manifested in differences in the percentage of canopy composed of *Inga vera*. *Inga vera* is regularly encouraged or planted as a shade tree in cafetales (Johnson 1999, 2000). We estimated the amount of *Inga vera* in the canopy by visually extending the 5-m radius plot into the canopy and estimating percent cover. A second management technique was manifested in the alteration of epiphyte cover by "cleaning" or removal activities. We measured epiphyte cover by randomly selecting 10 canopy branches within the 5-m radius plot and estimating percent coverage by epiphytes. Finally, the forest connectedness of each cafetal was assessed by walking the perimeter of the cafetal and estimating the percentage of the cafetal surrounded by forest.

To assess the influence of epiphyte removal on species richness and individual abundance, total number of species detected per transect were averaged within epiphyte cover classes (see Table 1; low cover: < 50%, A1, A4, C1, C2; high cover: > 50%, A2, A3, C3) and compared across foraging location and feeding guild. As they are unlikely to be affected by the removal of epiphytes from canopy trees, birds that foraged only on the ground or in the understory foragers were excluded from these analyses. To assess the influence of forest connectedness on species richness, total number of species detected per transect were averaged within connectedness classes (see Table 1; low connection: < 50%, A3, A4, C1, C2, high connection: > 50%, A1, A2, C3) and compared across foraging location and feeding guild.

Due to the small number of cafetales we were able to survey and the low variability in cafetal size and elevation, we were unable to assess the influence the effects of these variables on species richness. However, we did calculate Pearson's product moment correlation coefficients to assess relationships between species richness and forest connectedness. Non-parametric correlations (Spearman's Rho) were used to examine relationships between percent non-coffee in the understory, percent *Inga* in the canopy, epiphyte cover, and species richness. Foraging location and dietary guild comparisons across epiphyte abundance and forest connectedness classes were performed with Mann-Whitney *U*-tests. Sequential Bonferroni corrections were applied to control the group-wide type-I error rates at $\alpha = 0.05$ (Rice 1989). All analyses were performed with JMP IN 4.0.2 (SAS Institute 2000). Values

TABLE 2. Number of migrant and resident species, total number of species (migrants and residents combined) and the estimated number of species in samples of 200 individuals from rarefaction analysis.

| | Number of surveys | Migrants | Residents | Overall | Estimated (SD) |
|---|---|---|---|---|---|
| A1 | 4 | 9 | 75 | 84 | 74.2 (1.5) |
| A2 | 4 | 6 | 58 | 66 | 53.9 (0.3) |
| A3 | 4 | 9 | 61 | 70 | 65.0 (0.01) |
| A4 | 4 | 6 | 67 | 73 | 68.5 (1.1) |
| Total | | 13 | 93 | 106 | |
| C1 | 3 | 9 | 83 | 92 | 79.0 (0.01) |
| C2 | 4 | 10 | 103 | 113 | 89.7 (2.5) |
| C3 | 5 | 10 | 104 | 114 | 86.9 (2.8) |
| Total | | 15 | 128 | 143 | |
| Overall | | 17 | 160 | 181 | |

reported in the results section are mean ± 1 SE of untransformed variables.

## RESULTS

The eastern and western cafetales differed in the number of bird species detected (Table 2; see Appendix 1 for list of species). Cluster analysis separated the seven cafetales with respect to east and west Andean slopes (Fig. 2). The Altamira cafetales were more similar to one another than were the three Cucuchica cafetales. Of the 181 species detected during the transect surveys, 36 were detected only on the eastern slope while 66 were detected only on the western slope (see Appendix 1). The three western cafetales tended to contain more species than did the four eastern cafetales. The rarefaction analyses exhibited a similar pattern to the one provided by total counts (Table 2).

We detected no significant correlations between forest connectedness and total species richness (Pearson's r = 0.13, n = 7, $P$ = 0.78), migrant species richness (r = 0.06, n = 7, $P$ = 0.90), or resident species richness (r = 0.12, n = 7, $P$ = 0.80). Similarly, we detected no significant correlations between species richness and any of the cafetal habitat characteristics (all r < 0.2, all $P$ > 0.05).

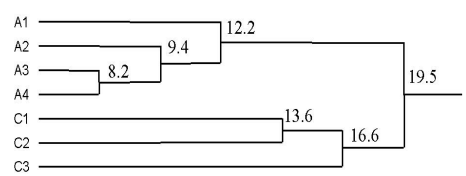


FIG. 2. Cluster analysis of species assemblages based on Ward's Hierarchical clustering of a presence/absence matrix for all studied cafetales. Numbers at nodes represent cluster multivariate distances. The Altamira cafetales are represented as A1–4, and the Cucuchica cafetales are represented as C1–3.

We detected no statistically significant differences in the number of species found in highand low epiphyte cafetales, although low epiphyte cafetales appeared to support more species than high epiphyte cafetales (Table 3). Of the 23 species detected only in high epiphyte cafetales, 11 are considered disturbance-sensitive (according to Parker *et al.* 1996) including the White-tipped Quetzal (*Pharomachrus fulgidus*). Similarly, we detected no effect of forest connectedness on species number for any of the migratory, foraging or dietary guilds, although cafetales with low forest connectedness appeared to support more species than cafetales with high forest connectedness (Table 3). Of the 30 species

TABLE 3. Numbers of species in each foraging location and dietary guild in relation to extent of epiphyte abundance and forest connectedness. Values shown are mean number of species per transect survey ± 1 SE. Terrestrial and understory foragers are excluded from the epiphyte analyses.

| | Epiphyte cover | | Forest connectedness | |
|---|---|---|---|---|
| | Low[1] | High[2] | Low[3] | High[4] |
| Total | 24.6 ± 2.9 | 18.9 ± 2.0 | 23.7 ± 3.4 | 20.1 ± 1.9 |
| Migrants | 2.3 ± 0.3 | 1.9 ± 0.2 | 2.3 ± 0.3 | 1.9 ± 0.2 |
| Residents | 22.3 ± 2.6 | 16.9 ± 2.0 | 21.4 ± 3.1 | 18.0 ± 1.9 |
| Foraging location[5] | | | | |
| Terrestrial | | | 2.1 ± 0.5 | 1.6 ± 0.1 |
| Understory | | | 10.7 ± 2.1 | 8.7 ± 0.6 |
| Midstory | 12.4 ± 1.9 | 10.2 ± 1.4 | 12.1 ± 2.1 | 10.5 ± 1.1 |
| Canopy | 15.8 ± 1.8 | 12.8 ± 1.3 | 15.4 ± 1.9 | 13.3 ± 1.4 |
| Main Diet[6] | | | | |
| Fruit | 3.3 ± 0.4 | 2.3 ± 0.03 | 3.0 ± 0.4 | 2.7 ± 0.4 |
| Fruit/Insect | 7.9 ± 0.8 | 6.5 ± 0.3 | 7.7 ± 0.9 | 6.8 ± 0.4 |
| Insect | 12.3 ± 2.1 | 10.0 ± 1.4 | 12.2 ± 2.1 | 10.1 ± 1.3 |
| Seeds | 2.5 ± 0.3 | 1.3 ± 0.2 | 2.2 ± 0.3 | 1.8 ± 0.6 |
| Nectar | 5.8 ± 1.5 | 4.5 ± 0.7 | 5.9 ± 1.4 | 4.4 ± 0.7 |

[1]A1, A4, C1, C2
[2]A2, A3, C3
[3]A3, A4, C1, C2
[4]A1,A2,C3
[5]Source: Parker *et al.* (1996)
[6]Sources: Meyer de Schauensee & Phelps (1978), Moermond & Denslow (1985), Remsen (1985), Karr *et al.* (1990).

detected only in highly connected cafetales, 14 are considered disturbance sensitive including the White-tipped Quetzal, Red-billed Scythebill (*Campylorhamphus trochilirostris*) and Red-crowned Ant-Tanager (*Habia rubica*). Interestingly, several species of Neotropical migrant thought to be highly disturbance-sensitive on the breeding grounds (e.g., Cerulean Warbler, *Dendroica cerulea*) were abundant in all cafetales (Jones *et al.* 2000).

Over the course of this study, 109 species (99 resident, 10 migrant) were observed in *Erythrina*, 63 of which (57 resident, 6 migrant) were observed actively probing the open flowers. Birds were observed in the shade trees more often than they were in the coffee understory (66%, 1985 observations). Only five species were consistently observed (= 25% of observations) in the coffee understory in the eastern cafetales, while 81 species were regularly observed in the coffee layer in the western cafetales. This represents 3% and 57% of the species detected on each of the two slopes, respectively. Several of these species were Neotropical migrants: Swainson's Thrush (*Catharus ustulatus*), Black-and-white Warbler (*Mniotilta varia*), Bay-breasted Warbler (*Dendroica castanea*), Blackpoll Warbler (*Dendroica striata*), American Redstart (*Setophaga ruticilla*), Northern Waterthrush (*Seiurus* *noveboracensis*), and Mourning Warbler (*Oporornis philadelphia*).

## DISCUSSION

Our results indicate that Venezuelan shade coffee plantations vary greatly in the number of species they support and in the composition of their species assemblages. Unfortunately, the low variability in the size and elevation of our study sites rendered us unable to test previously documented species richness relationships with plantation area and elevation (Greenberg *et al.* 1997b, Wunderle 1999). In a study of Dominican shade coffee plantations, Wunderle (1999) found no relationship with plantation size for migrant species richness but did for resident species richness. Other shade coffee studies have found evidence for a negative relationship between elevation and species richness in cafetal avifaunas (Greenberg *et al.* 1997b, Wunderle 1999). While it may have been possible to increase the elevation gradient surveyed in the study area, the size gradient displayed by our sites is typical for shade coffee plantations in the region (Ramoni-Perazzi pers. observ.). Species compositions of the eastern cafetales were more similar to one another than were those of the western cafetales; this is likely due to more pronounced differences in the landscape context surrounding the western cafetales.

The lack of a significant effect of forest connectedness on total species richness or richness within foraging or dietary guilds is likely due to the influence of landscape context (Wiens *et al.* 1993, Wiens 1994). Characteristics of the landscape surrounding the poorly connected cafetales (e.g., hedgerows, remnant trees in pastures) contribute to the overall habitat heterogeneity and may provide 'stepping-stones' for individuals; such landscape features may obscure any island effect (MacArthur & Wilson 1967, Boecklen 1986, Wiens 1994, Wunderle 1999).

Wunderle & Latta (1998: 280) stated that "a coffee plantation's attractiveness to birds is enhanced with abundance, variety, and consistency of food resources in a plantation". This statement is supported by our observation that 60% of all species detected in the cafetales in our study were observed at least once in *Erythrina* and one-third were observed investigating flowers. *Erythrina* is well known for its wildlife value (Feinsinger *et al.* 1979, Morton 1979, Steiner 1979, Toledo & Hernandez 1979, Bruneau 1997) and its presence in the shade layer may provide a valuable food resource for residents and migrants alike.

Epiphyte abundance appeared to have no significant relationship with species richness or individual abundance within foraging or dietary guilds, although abundance totals were generally higher in those cafetales with low epiphyte abundance. The only guild for which the results approached significance were canopy foragers and frugivores, both of whose abundances were negatively related to epiphyte abundance. This is contrary to previous suggestions that the removal of epiphyte biomass will likely have a serious impact on foraging opportunities for those species that forage in the midstory and canopy (Norris 1990, Sillett 1994) or are substrate-restricted foragers (*sensu* Robinson & Holmes 1982, Sillett *et al.* 1997). It is possible that the removal of epiphytic growth increased the delectability of midstory and canopy species, thereby creating the impression that low epiphyte cafetales contained more species than high epiphyte cafetales.

Another way in which the effect of cafetal management on birds can be assessed is by examining the use of the coffee understory by birds. Our two sites differed greatly in the number of species observed foraging in the coffee understory. Very few species were observed in the coffee understory at our eastern site. This is in accordance with previous studies and supports the view that coffee is poor habitat for birds (Wunderle & Latta 1996, 1998; Greenberg *et al.* 1997a, 1997b). Potentially contributing to the lack of activity in the coffee layer was the abundance of shrubby vegetation within the second-growth forests on the margins of the eastern cafetales that may be more attractive to forest understory birds than the coffee layer.

The regular observation of birds in the coffee layer at our western sites has at least two possible explanations. The first involves landscape context. Pastures and hedgerows surrounded two of these cafetales and many species typical of these habitats would often forage in the coffee layer on the edges of these cafetales, such as the Yellow-bellied Seedeater (*Sporophila nigricollis*). The second is that the birds observed in the coffee were not actually using the coffee as a foraging substrate but as a conduit to travel between any shrubs interspersed in the coffee layer. Although previous studies have documented the use of coffee as a foraging substrate for both migrants and residents (Wunderle & Latta 1998, Wunderle 1999, Johnson 2000), we encountered certain species active in the coffee layer that we did not expect to find there, such as the Black-and-White Warbler and Blue-necked Tanager (*Tangara cyanicollis*). More detailed observations of these individuals revealed that they were only foraging on the non-coffee plants in the coffee layer.

Our results support the conclusion that shade coffee plantations do provide habitat for residents and migrant species (Greenberg *et al.* 1997a, 1997b; Wunderle 1999, Wunderle & Latta 2000, Johnson 2000, Johnson & Sherry 2001). Granted, a short-term study based on presence/absence data does not replace a long-term assessment of breeding success of residents or overwintering survival and condition of migrants (Holmes *et al.* 1989, Marra & Holberton 1998, Wunderle & Latta 2000). We need to make comparisons to surrounding "natural" forests to determine the relative habitat value of cafetales within the landscape. However, our results do suggest that shade coffee plantations appear suitable for a diverse avifauna, at least in the short term. It appears that the wildlife value of these cafetales may be improved by increasing canopy tree diversity with the addition or encouragement of ecologically valuable species, such as *Erythrina*. Further, it has been suggested that the importance of shade coffee plantations for migrants may increase as the winter season progresses and many "natural" habitats show late-season insect population declines (Johnson 1999) and as nectar and fruit resources increase in *Inga* dominated cafetales (Greenberg *et al.* 1997b).

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APPENDIX 1. English name, scientific name, cafetal, foraging[1] and dietary[2] guilds for all species encountered in Venezuelan shade coffee plantations. Species not encountered during surveys are indicated by asterisks. Nearctic-Neotropical migrants denoted with (M). Scientific names taken from Parker *et al.* (1996).

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Little Tinamou* | *Crypturellus soui* | C3 | T | F, G |
| Bicolored Hawk* | *Accipiter bicolor* | C2 | C | C |
| Roadside Hawk* | *Buteo magnirostris* | A1-2, 4; C2 | C | C |
| Laughing Falcon* | *Herpetotheres cachinnans* | C1 | C | C |

APPENDIX 1. Continued.

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Bat Falcon* | *Falco rufigularis* | A2-3 | C, A | C |
| Band-tailed Pigeon | *Columba fasciata* | A2-4; C1 | C | F, G |
| Ruddy Pigeon | *Columba subvincaea* | A1-2, 4 | C | F |
| White-tipped Dove | *Leptotila verreauxi* | A1-4; C1-3 | T, U | F, G |
| Brown-throated Parakeet | *Aratinga pertinax* | A1 | C | F, G |
| Scarlet-fronted Parakeet | *Aratinga wagleri* | A1 | C | F, G |
| Green-rumped Parrotlet | *Forpus passerinus* | C1-3 | C | F, G |
| Orange-chinned Parakeet | *Brotogeris jugularis* | A1, 3; C1 | C | F, G |
| Blue-headed Parrot | *Pionus menstruus* | A2, 4 | C | F, G |
| Squirrel Cuckoo | *Piaya cayana* | A1-4; C1-3 | C | F, G |
| Smooth-billed Ani | *Crotophaga ani* | C2 | T, U , M, C | I |
| Striped Cuckoo | *Tapera naevia* | A2; C2-3 | T, U | I |
| Lesser Nighthawk* | *Chordeiles acutipennis* | C1 | A | I |
| Rufous-breasted Hermit | *Glaucis hirsuta* | A2-4 | U | I, N |
| Sooty-capped Hermit | *Phaethornis augusti* | C1 | U | I, N |
| Grey-chinned Hermit | *Phaethornis griseigularis* | A1, 4; C1-3 | U | I, N |
| Green Hermit | *Phaethornis guy* | A2-3; C1-3 | U | I, N |
| White-bearded Hermit | *Phaethornis hispidus* | A1-4 | U | I, N |
| Little Hermit | *Phaethornis longuemareus* | C2 | U | I, N |
| Lazuline Sabrewing | *Campylopterus falcatus* | C1-3 | U, M | I, N |
| White-necked Jacobin | *Florisuga mellivora* | C2-3 | M, C | I, N |
| Sparkling Violetear | *Colibri coruscans* | C1-3 | U, M, C | I, N |
| Brown Violetear | *Colibri delphinae* | C1-3 | M, C | I, N |
| Green Violetear | *Colibri thalassinus* | C1-3 | M, C | I, N |
| Black-throated Mango | *Anthracothorax nigricollis* | A1, 3; C1-2 | M, C | I, N |
| Violet-headed Hummingbird | *Klais guimeti* | C1 | U | I, N |
| Short-tailed Emerald | *Chlorostilbon poortmanni* | C2 | U, M, C | I, N |
| Fork-tailed Woodnymph | *Thalurania furcata* | A1-4; C1-3 | U, M | I, N |
| Shining-green Hummingbird | *Lepidopyga goudoti* | C2 | U, M, C | I, N |
| White-chinned Sapphire | *Hylocharis cyanus* | C3 | U, M, C | I, N |
| Golden-tailed Sapphire | *Chrysuronia oenone* | A1-4; C1, 3 | U, M, C | I, N |
| Steely-vented Hummingbird | *Amazilia saucerottei* | A1-4; C1-3 | U, M, C | I, N |
| Rufous-tailed Hummingbird | *Amazilia tzacatl* | A1-4; C1-3 | U, M, C | I, N |
| White-vented Plumeleteer | *Chalybura buffonii* | A2, 4; C1, 3 | U, M | I, N |
| Violet-fronted Brilliant | *Heliodoxa leadbeateri* | C1-3 | U, M | I, N |
| Bronzy Inca | *Coeligena coeligena* | C1-3 | U, M | I, N |
| Collared Inca | *Coeligena torquata* | C1 | U, M, C | I, N |
| Booted Racket-tail | *Ocreatus underwoodii* | C2-3 | U | I, N |
| Long-billed Starthroat | *Heliomaster longirostris* | C2 | C | I, N |
| Rufous-shafted Woodstar | *Chaetocercus jourdanii* | C2-3 | U, M, C | I, N |
| White-tipped Quetzal | *Pharomachrus fulgidus* | C3 | M | F |
| Masked Trogon | *Trogon personatus* | C1-2 | M | F |
| Collared Trogon | *Trogon violaceus* | A1-4 | C | F |
| Moustached Puffbird* | *Malacoptila mysticalis* | C2 | U | I |
| Yellow-billed Toucanet | *Aulacorhynchus calorhynchus* | C3 | C | F |

APPENDIX 1. Continued.

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Many-banded Aracari | *Pteroglossus pluricinctus* | A2-4 | C | FI |
| Scaled Piculet | *Picumnus squamulatus* | A1, 3-4; C2 | C | I |
| Red-crowned Woodpecker | *Melanerpes rubricapillus* | A1-4; C1-3 | U, M, C | I |
| Smoky-brown Woodpecker | *Venilornis fumigatus* | A1 | M, C | I |
| Red-rumped Woodpecker | *Venilornis kirkii* | A1, 4 | M, C | I |
| Golden-olive Woodpecker | *Piculus rubiginosus* | C3 | C | I, N |
| Lineated Woodpecker | *Dryocopus lineatus* | C1, 3 | C | I |
| Ruddy Woodcreeper | *Dendrocincla homochroa* | A2-3 | T, U | I |
| Wedge-billed Woodcreeper | *Glyphorynchus spirurus* | A1-4 | U, M | I |
| Strong-billed Woodcreeper | *Xiphocolaptes promeropirhynchus* | A2, 4 | M, C | I |
| Buff-throated Woodcreeper | *Xiphorhynchus guttatus* | C3 | U, M, C | I |
| Straight-billed Woodcreeper | *Xiphorhynchus picus* | C3 | M | I |
| Streak-headed Woodcreeper | *Lepidocolaptes souleyetii* | A1-4; C1-3 | U, M | I |
| Red-billed Scythebill | *Campylorhamphus trochilirostris* | C3 | U, M | I |
| Pale-breasted Spinetail | *Synallaxis albescens* | C1-3 | U | I |
| Crested Spinetail | *Cranioleuca subcristata* | A1, 4; C3 | M, C | I |
| Streaked Xenops | *Xenops rutilans* | A1, 3 | C | I |
| Barred Antshrike | *Thamnophilus doliatus* | C2-3 | U, M | FI |
| White-fringed Antwren | *Formicivora grisea* | C2-3 | U, M | I |
| Sooty-headed Tyrannulet | *Phyllomyias griseiceps* | C2-3 | C | I |
| Black-capped Tyrannulet* | *Phyllomyais nigrocapillus* | C1 | C | FI |
| Paltry Tyrannulet | *Zimmerius vilisimus* | A1, 3 | C | FI |
| Golden-faced Tyrannulet | *Zimmerius viridiflavus* | C1-3 | U, M, C | F |
| Mouse-colored Tyrannulet | *Phaeomyias murina* | C2-3 | C | I |
| Forest Elaenia | *Myiopagis gaimardii* | C1 | C | FI |
| Yellow-bellied Elaenia | *Elaenia flavogaster* | A1, 4; C1-3 | C | FI |
| White-banded Tyrannulet | *Mecocerculus stictopterus* | C2 | C | I |
| Ochre-bellied Flycatcher | *Mionectes oleagineus* | C1-3 | U, M, C | FI |
| Olive-striped Flycatcher | *Mionectes olivaceus* | A2-4; C1-3 | U, M | I |
| Slaty-capped Flycatcher | *Leptopogon superciliaris* | A1-4; C1-3 | U, M | I |
| Scale-crested Pygmy-Tyrant | *Lophotriccus pileatus* | C3 | U, M | I |
| Pale-eyed Pygmy-Tyrant | *Atalotriccus pilaris* | A2; C1 | M, C | I |
| Common Tody-Flycatcher | *Todirostrum cinereum* | C1 | U, M, C | I |
| Yellow-olive Flycatcher | *Tolmomyias sulphurescens* | C1-3 | C | I |
| Bran-colored Flycatcher | *Myiophobus fasciatus* | C1-2 | U | I |
| Cinnamon Flycatcher | *Pyrrhomyias cinnamomea* | A2-4 | C | I |
| Olive-sided Flycatcher (M) | *Contopus borealis* | A1, 3; C1-3 | C | I |
| Tropical Pewee | *Contopus cinereus* | A1; C2-3 | U, M, C | I |
| Greater Pewee | *Contopus fumigatus* | C3 | C | I |
| Willow/Alder Flycatcher (M) | *Empidonax traillii/alnorum* | C3 | M, C | I |
| Black Phoebe | *Sayornis nigrescens* | A2; C2-3 | T, U, M, C | I |
| Dusky-capped Flycatcher | *Myiarchus tuberculifer* | A2, 4; C2-3 | M, C | I |
| Lesser Kiskadee | *Pitangus lictor* | A2 | U | FI |
| Greater Kiskadee | *Pitangus sulphuratus* | A2; C1-3 | T, U, M, C | FI |
| Boat-billed Flycatcher | *Megarynchus pitangua* | C1-3 | C | A |

APPENDIX 1. Continued.

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Rusty-margined Flycatcher | *Myiozetetes cayanensis* | A1, 3-4; C1-3 | C | I |
| Social Flycatcher | *Myiozetetes similis* | A1-4; C1-3 | M, C | FI |
| Golden-crowned Flycatcher | *Myiodynastes chrysocephalus* | C2-3 | M, C | I |
| Streaked Flycatcher | *Myiodynastes maculatus* | A1-4; C1-3 | M, C | FI |
| Piratic Flycatcher | *Legatus leucophaius* | A1-4; C1-3 | C | FI |
| Tropical Kingbird | *Tyrannus melancholicus* | A1-4; C1-3 | C | FI |
| Cinnamon Becard | *Pachyramphus cinnamomeus* | C2-3 | C | FI |
| Cinereous Becard | *Pachyramphus rufus* | C2-3 | C | FI |
| Black-tailed Tityra | *Tityra cayana* | C2-3 | C | FI, C |
| Masked Tityra | *Tityra semifasciata* | C1, 3 | C | FI, C |
| Striped Manakin | *Machaeropterus regulus* | A2 | U, M | F |
| White-ruffed Manakin | *Corapipo leucorrhoa* | C2 | U | F |
| Golden-headed Manakin | *Pipra erythrocephala* | C1-2 | U, M | F, G |
| Golden-breasted Fruiteater | *Pipreola aureopectus* | C2 | C | F |
| Moustached Wren | *Thryothorus genibarbis* | A1-4; C1-3 | U | I |
| Buff-breasted Wren | *Thryothorus leucotis* | C3 | U | I |
| Rufous-and-white Wren | *Thryothorus rufalbus* | A1, 3-4; C1-3 | U | I |
| Rufous-breasted Wren | *Thryothorus rutilus* | C1-2 | U | I |
| House Wren | *Troglodytes aedon* | A1, 4; C1-2 | T, U | I |
| Grey-breasted Wood-wren | *Henicorhina leucophrys* | A1, 4; C2-3 | U | I |
| Nightingale Wren | *Microcerculus marginatus* | C2 | T, U | I |
| Spotted Nightingale-Thrush* | *Catharus dryas* | A1 | U | FI |
| Swainson's Thrush (M) | *Catharus ustulatus* | C2 | U, M | FI |
| Yellow-legged Thrush | *Platycichla flavipes* | A2-3; C1-3 | M, C | FI |
| White-necked Thrush | *Turdus albicollis* | C2 | U, M | FI |
| Glossy-black Thrush | *Turdus serranus* | C2 | C | FI |
| Black-billed Thrush | *Turdus ignobilis* | C1-2 | T, U, M, C | FI |
| Pale-breasted Thrush | *Turdus leucomelas* | A1-4; C1, 3 | T, U, M, C | FI |
| Bare-eyed Thrush | *Turdus nudigenis* | C1-3 | T, U, M, C | FI |
| Pale-vented Thrush | *Turdus obsoletus* | A1 | T, U, M, C | FI |
| Black-hooded Thrush | *Turdus olivater* | A1, 3 | C | FI |
| Tropical Gnatcatcher | *Polioptila plumbea* | A1, 4 | U, M, C | I |
| Blue-black Grassquit | *Volatina jacarina* | A1 | U | G |
| Gray Seedeater | *Sporophila intermedia* | C1 | T | FI |
| Black-and-white Seedeater | *Sporophila luctuosa* | A1, 4 | T, U | G |
| Yellow-bellied Seedeater | *Sporophila nigricollis* | A1, 4; C1 | U | G |
| Lesser Seed-Finch | *Oryzoborus angolensis* | C2 | U, M | F, G |
| Pectoral Sparrow | *Arremon taciturnus* | A2 | T | FI |
| Moustached Brush-Finch | *Atlapetes albofrenatus* | C3 | T, U, M | I |
| Rose-breasted Grosbeak (M) | *Pheucticus ludovicianus* | C3 | M, C | FI |
| Streaked Saltator | *Saltator albicollis* | A1; C1, 3 | M, C | FI, G, N |
| Grayish Saltator | *Saltator coerulescens* | C1-3 | M, C | FI, G, N |
| Buff-throated Saltator | *Saltator maximus* | A1-4; C1-3 | M, C | FI, G, N |
| Blue-black Grosbeak | *Passerina cyanoides* | A1 | U | G |
| Black-faced Tanager* | *Schistochlamys melanopis* | C2 | U, M, C | F, G |

APPENDIX 1. Continued.

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Magpie Tanager | *Cissopsis leveriana* | A1, 4; C1-3 | U, M, C | F |
| Fulvous-headed Tanager | *Thlypopsis fulviceps* | C3 | U, M, C | FI |
| Guira Tanager | *Hemithraupis guira* | A1-4; C1-3 | C | I |
| Grey-headed Tanager | *Eucometis penicillata* | A1-4 | U, M | FI |
| White-shouldered Tanager | *Tachyphonus luctuosus* | A1-4 | M, C | FI |
| White-lined Tanager | *Tachyphonus rufus* | A1-4; C1-3 | U, M, C | FI |
| Red-crowned Ant-Tanager | *Habia rubica* | A1 | U, M | FI |
| Hepatic Tanager | *Piranga flava* | A1-4; C2-3 | C | FI |
| White-winged Tanager | *Piranga leucoptera* | C1, 3 | C | FI |
| Summer Tanager (M) | *Piranga rubra* | A1, 3-4; C3 | C | FI |
| Silver-beaked Tanager | *Ramphocelus carbo* | A1, 3-4 | U, M, C | FI |
| Crimson-backed Tanager | *Ramphocelus dimidiatus* | C1-3 | U, M | FI |
| Blue-grey Tanager | *Thraupis episcopus* | A1-4; C1-3 | C | FI |
| Palm Tanager | *Thraupis palmarum* | A1-4; C1-3 | C | FI |
| Thick-billed Euphonia | *Euphonia laniirostris* | A1, 3-4; C2-3 | C | F |
| Blue-hooded Euphonia | *Euphonia musica* | A1 | C | F |
| Orange-bellied Euphonia | *Euphonia xanthogaster* | C3 | U, M, C | F |
| Burnished-buff Tanager | *Tangara cayana* | A1-4; C1-3 | U, M, C | FI |
| Blue-necked Tanager | *Tangara cyanicollis* | A1-4; C1-3 | C | FI |
| Speckled Tanager | *Tangara guttata* | A1-4; C1-3 | C | FI |
| Bay-headed Tanager | *Tangara gyrola* | A1-4; C1-3 | C | FI |
| Rusty Flower-piercer | *Diglossa baritula* | C3 | M, C | I, N |
| Swallow-Tanager | *Tersina viridis* | A1-4 | C | FI |
| Black-and-white Warbler (M) | *Mniotilta varia* | A1-4; C1-3 | U, M, C | I |
| Golden-winged Warbler (M) | *Vermivora chrysoptera* | C2-3 | U | I |
| Tennessee Warbler (M) | *Vermivora peregrina* | A1-4; C1-3 | U, M, C | FI, N |
| Tropical Parula | *Parula pitiayumi* | A2-3 | M, C | I |
| Bay-breasted Warbler (M) | *Dendroica castanea* | A1-4; C1-3 | M, C | I, N |
| Cerulean Warbler (M) | *Dendroica cerulea* | A1-4; C1-3 | M, C | I, N |
| Blackburnian Warbler (M) | *Dendroica fusca* | A1-4; C1-3 | M, C | I |
| Yellow Warbler (M) | *Dendroica petechia* | A2 | U, M | I, N |
| Blackpoll Warbler (M) | *Dendroica striata* | A3; C1-3 | M, C | I, N |
| American Redstart (M) | *Setophaga ruticilla* | A1-4; C1-3 | M, C | I, N |
| Northern Waterthrush (M) | *Seiurus noveboracensis* | C1-2 | T, U | I |
| Mourning Warbler (M) | *Oporornis philadelphia* | A2-3; C1-2 | U, M, C | I |
| Canada Warbler (M) | *Wilsonia canadensis* | A2 | U, M | I |
| Slate-throated Redstart | *Myioborus miniatus* | A1-4; C1-3 | M | I |
| Golden-crowned Warbler | *Basileuterus culicivorus* | A1-4; C1-3 | U, M | I |
| Three-striped Warbler | *Basileuterus tristriatus* | A1; C2-3 | U | I |
| White-eared Conebill | *Conirostrum leucogenys* | C1, 3 | C | I, N |
| Bananaquit | *Coereba flaveola* | A1-4; C1-3 | M, C | F, N |
| Rufous-browed Peppershrike | *Cyclarhis gujanensis* | A1, 3-4; C2-3 | M, C | I |
| Brown-capped Vireo | *Vireo leucophrys* | C2-3 | M, C | I |
| Red-eyed Vireo | *Vireo olivaceus* | A1, 3-4; C1-3 | C | FI |
| Golden-fronted Greenlet | *Hylophilus aurantiifrons* | C1, 3 | M, C | I |

APPENDIX 1. Continued.

| English names | Scientific names | Cafetal | Foraging | Diet |
|---|---|---|---|---|
| Scrub Greenlet | *Hylophilus flavipes* | A1-4; C2 | M, C | I |
| Yellow-backed Oriole | *Icterus chrysater* | A1-4; C1-3 | C | FI |
| Crested Oropendola | *Psarocolius decumanus* | A1-4; C1-3 | C | FI |
| Giant Cowbird | *Scaphidura oryzivora* | A1, 3; C1-3 | T, U, M, C | F |
| Dark-backed Goldfinch | *Carduelis psaltria* | A1; C3 | C | G |
| Yellow-bellied Siskin | *Carduelis xanthogastra* | C2 | C | G |
| Green Jay | *Cyanocorax yncas* | C2-3 | C | A |

[1]Source: Parker *et al.* (1996). Foraging locations coded as: T = terrestrial, U = understory, M = midstory, C = canopy, A = aerial.

[2]Sources: Meyer de Schauensee & Phelps (1978), Moermond & Denslow (1985), Remsen (1985), Karr *et al.* (1990). Dietary guilds coded as follows: F = frugivore, FI = frugivore/insectivore, I = insectivore, G = granivore, N = nectarivore, C = carnivore, A = all food groups.