*Wilson Bulletin* 117(1):92–99, 2005

# USING CANOPY AND UNDERSTORY MIST NETS AND POINT COUNTS TO STUDY BIRD ASSEMBLAGES IN CHACO FORESTS

ENRIQUE J. DERLINDATI[1,2] AND SANDRA M. CAZIANI[1]

ABSTRACT.—We sampled birds with mist nets and point counts in old-growth and second-growth Chaco forest in Argentina to compare the contribution of each method to estimates of species abundance and diversity. We captured 53 species with mist nets (13 exclusively), and detected 75 species on point counts (43 exclusively). Species richness estimated by rarefaction curves did not differ between methods, except in old-growth understory, where point counts detected fewer species than mist nets. Both methods showed similar patterns of bird diversity and distribution, although point counts revealed more differences between forest layers and forest types. Mist netting contributed to the detection of cryptic or secretive species, especially in the understory, but large-bodied (>200 g) species were detected by point counts alone. Multivariate analysis discerned guilds and species associated with different forest layers and types. Point counts seem to better reflect relative abundance, whereas mist nets may be more sensitive to bird activity (e.g., movements between resources). The simultaneous use of both techniques enhances the description of bird communities, and birds' use of habitats. *Received 19 June 2003, accepted 7 November 2004.*

Mist nets and point counts have been widely used in the study of Neotropical birds (Whitman et al. 1997, Rappole et al. 1998), and a combination of the two techniques might be the most effective methodological approach for monitoring bird assemblages (Wallace et al. 1996, Gram and Faaborg 1997, Rappole et al. 1998, Poulin et al. 2000, Blake and Loiselle 2001, Wang and Finch 2002). Although point counts have been used extensively (Blake 1992, Thompson et al. 1999, Verner and Purcell 1999, Codesido and Bilenca 2000, Mills et al. 2000), they depend on the researcher's training in identification of species (Whitman et al. 1997, Blake and Loiselle 2001). Mist nets are relatively easy to use and they simplify species identification (Herrera 1978, Ralph et al. 1996); however, mist-net capture data represent species activity rather than abundance (Remsen and Good 1996), and use of mist nets is typically confined to the understory (Karr 1976, 1977, 1981; Schewske and Brokaw 1981; Blake and Rougès 1997; Gram and Faaborg 1997; Restrepo and Gómez 1998; Gardali et al. 2000), thus excluding most canopy birds (Karr 1976, Caziani 1996, Remsen and Good 1996, Rappole et al. 1998, Blake and Loiselle 2001, Wang and Finch 2002). Few investigators have used mist nets systematically in more than one forest layer (Lovejoy 1974, Karr 1976), and none have analyzed the contribution of simultaneous mist netting and point counts in the study of bird assemblages in different forest layers.

In this study, we compare the results obtained from mist nets and point counts as part of a larger study to compare the vertical distribution of birds and their resources between two different forest habitats in the semi-arid Chaco. The vertical distribution of birds has mainly been studied using different techniques in multi-layered tropical rainforests with high tree canopies (Anderson and Shugart 1974, Lovejoy 1974, Karr 1976, Loiselle 1987, Terborgh et al. 1990, Blake and Loiselle 2001, Winkler and Preleuthner 2001). The subtropical, semi-arid Chaco forest, with its low tree canopy and relatively simple vertical structure, provides an ideal system for testing the use of canopy and understory mist nets and point counts to study bird assemblages. Our objectives in this study were to (1) evaluate the use of canopy mist nets in a semi-arid forest with a low tree canopy, (2) compare estimates of species richness and abundance based on point counts and mist nets, and (3) compare the ability of point counts and mist nets to detect differences in bird assemblages between canopy and understory, and between two forest types (old-growth forest and second-growth forest).

[1] Facultad de Ciencias Naturales y Consejo de Investigaciones, Univ. Nacional de Salta—CONICET, Buenos Aires 177, 4400 Salta, Argentina.
[2] Corresponding author; e-mail: dvazquez@unsa.edu.ar

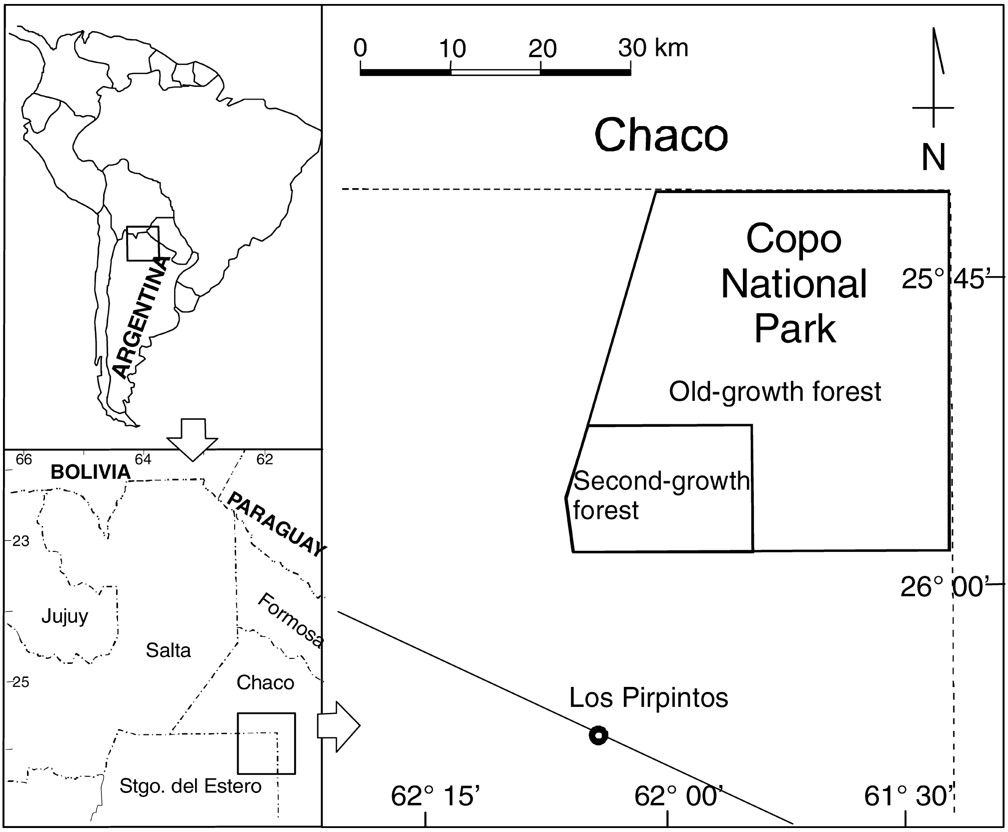


FIG. 1. Copo National Park study area, Santiago del Estero province, northwestern Argentina.

## METHODS

*Study area.*—Copo National Park (114,000 ha, 160 m elevation) is located in Santiago del Estero Province, Argentina (25° 55′ S, 62° 05′ W). The area is considered a key preserve for threatened Neotropical birds (Wege and Long 1995). Extensive stands of old-growth forest persist in the northern and eastern portions of the park; the southwestern sector was selectively logged in the 1950s (Fig. 1). The climate is seasonal, with 80% of annual rainfall occurring October–March. Summer temperatures in the region are extreme (mean maximum = 47° C; Prohaska 1959).

The dominant vegetation is thorny, semideciduous forest dominated by quebracho colorado santiagueño (*Schinopsis lorentzii*), quebracho blanco (*Aspidosperma quebracho-blanco*), and mistol (*Zizyphus mistol*), and is interrupted by belts of natural grasslands associated with ancient river beds. The understory is a dense, shrubby layer (4 m mean height), dominated by sacha poroto (*Capparis retusa*; Protomastro 1988, Tálamo and Caziani 2003). Above this layer, mistol forms a sparse layer with both quebracho species, the tops of which attain a mean height of 12 m (López de Casenave et al. 1998).

*Sampling.*—We conducted bird surveys during six periods in Copo National Park (December 1998, March 1999, August 1999, December 1999, April 2000, and September 2000) in two forest types: old-growth and second-growth (i.e., 50 years after selective logging). In each forest type, we established eight mist-net stations, 100 to 200 m apart, four in the understory (0–3 m above ground) and four in the canopy (5–8 m above the shrubby layer). At each station, we placed one mist net, 12.5 m long × 2.8 m high (36-mm mesh). We operated nets for 3 days in each type of forest during each survey period (Ralph et al.

1996), except for the second-growth forest in December 1998, when only 1 day of sampling occurred; thus, we mist-netted for 18 days in old-growth and 16 days in second-growth. We opened nets before sunrise and operated them for 3–6 hr/day when possible, but we often had to close nets early due to temperature and weather conditions. Canopy nets were installed with a modification of the technique described by Humphrey et al. (1968), with trees supporting a system of pulleys and ropes. We added vertical aluminum poles for additional support. For each bird captured, we recorded species, forest type, layer, date, time, weight, standard morphological measurements, and sex. Each bird was banded with National Park Administration aluminum bands and released. Data were expressed as captures per 100 mist-net hr (MNH), including recaptures (Bibby et al. 1992).

We established eight point-count stations, at least 400 m apart, in each of the two forest types. In each survey period, we twice visited all point-count stations to conduct 10-min unlimited-distance point counts on 2 consecutive days, reversing the order of visits to avoid time-of-day bias. Surveys began at sunrise and were completed within 3 hr (Bibby et al. 1992, Ralph et al. 1996, Gram and Faaborg 1997). During each point count, we recorded species and number of individuals detected by sight or sound, and the forest layer in which each individual was detected for the first time. Layers were defined as understory (0–4 m) and canopy (>4 m). Every individual seen or heard was recorded only once, so that observations per layer were considered to be independent, and layers at a single station were treated as separate treatments in the analysis. Birds over-flying the canopy were not included. Results are expressed as number of detections per 10 min (Bibby et al. 1992). One observer (EJD) conducted all point counts.

Guilds were defined according to previous studies in the area (Caziani 1996, López de Casenave et al. 1998) as follows: omnivores, carnivores, nectivores, terrestrial granivores, arboreal granivores, terrestrial insectivores, bark insectivores, foliage insectivores, short-flight insect hunters, long-flight insect hunters, frugivores, and undergrowth granivores.

*Statistical analyses.*—We compared species richness using rarefaction curves, given that the number of individuals in a sample can influence the number of recorded species (James and Rathbun 1981). Rarefaction estimates the number of species expected from different samples, based on multiple random sampling of increasing abundance. Curves were built with 1,000 iterations for each abundance level using Program EcoSim (Gotelli and Entsminger 2002). The program calculates a 95% confidence interval for each mean species richness value.

For each survey method, we compared total records, total records by guild, and records of the most common species. We employed a factorial design with forest type as the first factor (two levels: old-growth forest and second-growth forest, a = 2) and layer as the second factor (two levels: understory and canopy, b = 2). Replicates by treatment (forest × layer) were the four mist-net stations ($r = 4$) and the eight point-count stations ($r = 8$), respectively. Seasonality was not considered; however, the six survey periods were included in the analysis as repeated measures, using a split-plot ANOVA (Von Ende 1993). Assumptions of ANOVA were satisfied by logarithmic transformation of the data. For the between-factor comparisons, error degrees of freedom were calculated as $[a \times b \times (r - 1)]$; due to the collapse of three nets in one survey period (two canopy nets and one understory net), 3 degrees of freedom were subtracted from the error degrees of freedom.

*Detrended correspondence analysis.*—To describe the association of bird species and guilds with treatments (forest × layer), we applied Detrended Correspondence Analysis (DCA) to the matrices of total captures by net stations and total detections by point-count stations using Program PC-ORD (Gauch 1982, McCune and Mefford 1997). DCA is an ordination technique that groups species and stations in a two-dimensional scatterplot, where species lying close together show similar use of forest layers and forest types, and forest layers and types lying close together have similar avian communities.

## RESULTS

We recorded 91 species, including 13 recorded only with mist nets and 43 only with point counts. An additional 17 species were observed either flying over the study area or

TABLE 1. Mist-net hr (MNH), captures (C), captures per 100 MNH, species richness (S), and mean captures ± SE by forest type and by layer, Copo National Park, northwestern Argentina, 1998–2000. MNH is lower in second-growth forest because we lost one canopy mist net in three sample periods because of extreme weather, and we had only 1 day of sampling in December 1998.

| | Old-growth forest | | | | | Second-growth forest | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Layer | MNH | C | C per 100 MNH | S | Mean ± SE | MNH | C | C per 100 MNH | S | Mean ± SE |
| Understory | 360 | 134 | 37.2 | 40 | 49.6 ± 7.5 | 229 | 90 | 39.2 | 35 | 51.8 ± 8.8 |
| Canopy | 320 | 178 | 55.6 | 37 | 41.6 ± 6.5 | 202 | 105 | 52.0 | 37 | 41.1 ± 7.6 |
| Total | 680 | 312 | 45.8 | 45 | 45.6 ± 6.9 | 431 | 195 | 45.2 | 46 | 46.4 ± 8.1 |

outside of the sampling periods. The two methods combined detected 80% of the species reported for forest habitat in the area (Caziani 1996).

We captured 507 birds of 48 species in 1,111 MNH (34 days; Table 1). Recaptures represented 1.53% of total captures. We detected 907 individuals of 78 species in 32 point-count hr (Table 2). Considering both mist-net captures and point-count detections, 10 species were exclusive to old-growth forest, 15 to second-growth forest, 28 to the canopy, and 29 to the understory. Raptors (Accipitridae and Falconidae), parrots and parakeets (Psittacidae), woodcreepers (Dendrocolaptidae), warblers (Parulidae), tanagers (Thraupidae), and caciques (Icteridae) dominated canopy records. Tinamous (Tinamidae), seriemas (Cariamidae), nightjars (Caprimulgidae), antbirds (Formicariidae), and tapaculos (Rhinocryptidae) were recorded only in the understory. Expected species richness (Fig. 2) was similar between census methods, forest layers, and forest types, as confidence intervals on rarefaction curves overlapped in all cases, with the exception of point counts in old-growth forest understory, which had significantly fewer species.

Using mist nets, the species most often detected were Creamy-bellied Thrush (*Turdus amaurochalinus*), White-crested Elaenia (*Elaenia albiceps*), Small-billed Elaenia (*E. parvirostris*), Red-crested Finch (*Coryphospingus cucullatus*), and Red-eyed Vireo (*Vireo olivaceus*), representing 48% of total captures. Only White-crested Elaenias were captured more frequently in old-growth forest ($F_{1,9}$ = 13.65, $P$ = 0.005). Bark insectivores were captured more often in the understory than the canopy ($F_{1,9}$ = 5.27, $P$ = 0.047), but no other guild showed a significant difference between layers.

Using point counts, the species most often detected were Chaco Chachalaca (*Ortalis canicollis*), Masked Gnatcatcher (*Polioptila dumicola*), Picazuro Pigeon (*Columba picazuro*), Stripe-backed Antbird (*Myrmorchilus strigilatus*), and Creamy-bellied Thrush, representing 52% of total detections. The first three species were detected more often in second-growth forest ($F_{1,28}$ = 4.47, $P$ = 0.040; $F_{1,28}$ = 3.76, $P$ = 0.060; and $F_{1,28}$ = 4.61, $P < 0.001$, respectively); Chaco Chachalaca was more abundant in the canopy ($F_{1,28}$ = 10.03, $P$ = 0.004), and Stripe-backed Antbird and Creamy-bellied Thrush were more abundant in the understory ($F_{1,28}$ = 21.40, $P < 0.001$ and $F_{1,28}$ = 7.7, $P$ = 0.009). Total point-count detections per 10 min were significantly higher in old-growth forest ($F_{1,28}$ = 6.85, $P$ =

TABLE 2. Point count hours (PCH), total birds detected (D), detections per 10 min, species richness (S), and mean detections ± SE, by forest type and layer, Copo National Park, northwestern Argentina, 1998–2000.

| | Old-growth forest | | | | | Second-growth forest | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Layer | PCH | D | D per 10 min | S | Mean ± SE | PCH | D | D per 10 min | S | Mean ± SE |
| Understory | 8 | 222 | 4.6 | 29 | 29.7 ± 3.3 | 8 | 175 | 3.6 | 38 | 24.1 ± 1.9 |
| Canopy | 8 | 289 | 6.0 | 40 | 35.6 ± 2.9 | 8 | 221 | 4.6 | 41 | 34.1 ± 6.7 |
| Total | 16 | 511 | 10.6 | 52 | 76.8 ± 4.4 | 16 | 396 | 8.2 | 61 | 73.5 ± 7.1 |

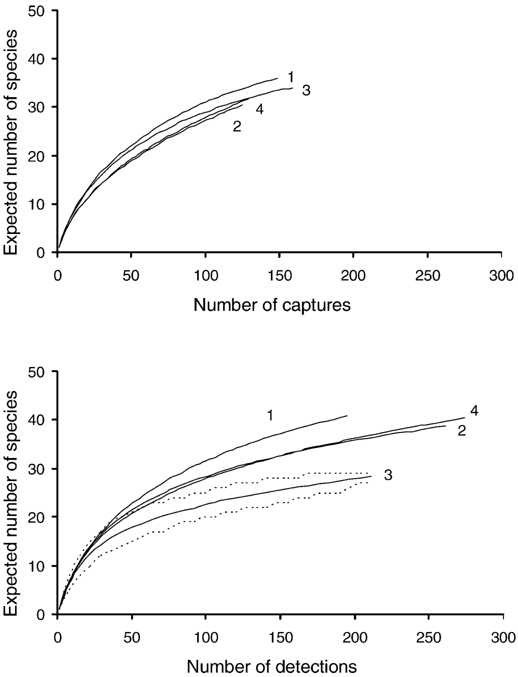


FIG. 2. Species rarefaction curves show the expected number of species related to the number of captures in mist nets (top) and number of detections in point counts (bottom), by forest type and layer, Copo National Park, northwestern Argentina, 1998–2000. Dotted lines correspond to the 95% confidence interval for the expected number of species detected in old-growth forest understory. Confidence intervals on other curves were omitted for clarity. (1) Second-growth forest understory, (2) second-growth forest canopy, (3) old-growth forest understory, and (4) old-growth forest canopy.

0.014) and in the canopy ($F_{1,28} = 4.98$, $P = 0.034$; Table 2). Short-flight insect hunters, omnivores, and terrestrial granivores were all more abundant in the understory than in the canopy ($F_{1,28} = 7.40$, $P = 0.011$; $F_{1,28} = 42.37$, $P < 0.001$; and, $F_{1,28} = 32.8$, $P < 0.001$, respectively). Bark insectivores and arboreal granivores were more abundant in the canopy ($F_{1,28} = 55.07$, $P < 0.001$; $F_{1,28} = 22.55$, $P < 0.001$). Terrestrial insectivores had higher abundances in second-growth forest ($F_{1,28} = 7.4$, $P < 0.001$), and undergrowth granivores were more abundant in old-growth forest ($F_{1,28} = 18.8$, $P < 0.001$).

DCA analysis applied to the point-count matrix (Fig. 3A) clearly distinguished bird assemblages between canopy and understory (Axis 1), and between old-growth and second-growth forest, especially for understory (Axis 2). Bark insectivores and arboreal granivores appeared to be associated with the canopy for both forest types. Terrestrial granivores characterized the understory. DCA analysis applied to mist-net captures (Fig. 3B) also distinguished bird assemblages between layers and forest types, though less clearly. Only two guilds (bark insectivores and short-flight insect hunters) showed clear patterns; both guilds were associated with the canopy.

## DISCUSSION

In agreement with other studies, we detected more species with point counts than with mist nets (Gram and Faaborg 1997; Whitman et al. 1997; Blake and Loiselle 2000, 2001; Wang and Finch 2002). The major advantage of mist nets is that less experience in species identification is required, and, in fact, censusing with mist nets may aid the observer in gaining familiarity with different species (Ralph et al. 1995). In the understory, mist nets can be more effective than point counts in detecting smaller birds, or those with more cryptic plumage or secretive behavior (Mason 1996; Rappole et al. 1998; Blake and Loiselle 2000, 2001; Wang and Finch 2002). However, canopy mist nets require greater effort to install (Humphrey et al. 1968, Meyers and Pardieck 1993), and they are more affected by weather (e.g., wind entanglement in treetops). Canopy nets do overcome one of the principal deficiencies of mist nets: only sampling the lowest forest layer (Blake 1992, Remsen and Good 1996, Rappole et al. 1998). Some species, however, are not detectable with nets due to size or behavior (Blake and Loiselle 2001, Wang and Finch 2002).

On the other hand, point counts are easier to conduct, and are more efficient in terms of data collected per unit of effort (Bibby et al. 1992). However, point-count detections may vary according to foliage density, visibility, and the transmission and perception of sounds during censuses (Schieck 1997). This may account for the lower richness estimate obtained by point counts in the understory of old-growth forest (Fig. 2), the layer with highest foliage density (Lopez de Casenave et al. 1998; EJD and SMC unpubl. data). Furthermore, point counts require training in species identification, particularly knowledge of vo-

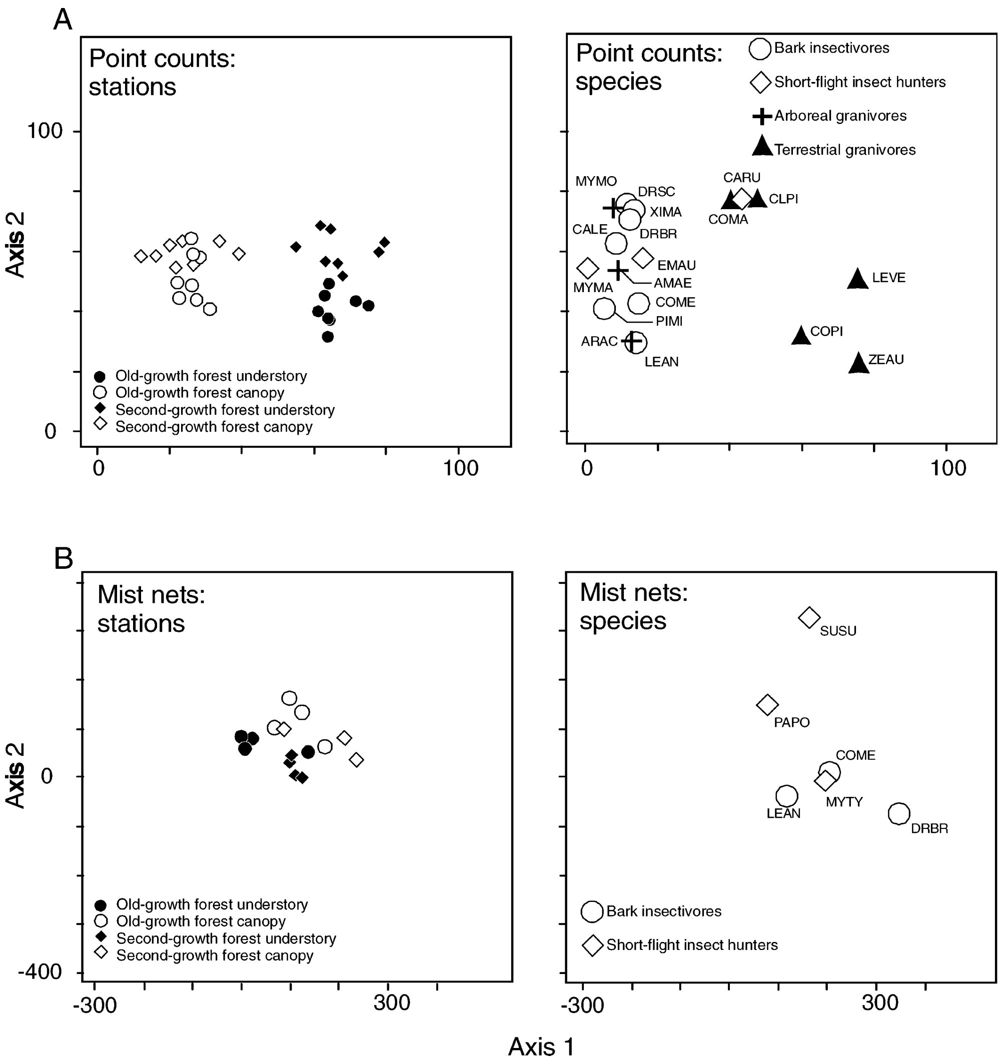


FIG. 3. Detrended Correspondence Analysis (DCA) using (A) point-count and (B) mist-net matrices, Copo National Park, northwestern Argentina, 1998–2000. For clarity, we show only species belonging to guilds that showed strong associations with forest type or layer. Axis 1 appears to be associated with layers and axis 2 with forest type. Species codes: AMAE (*Amazona aestiva*), ARAC (*Aratinga acuticaudata*), CALE (*Campephilus leucopogon*), CARU (*Casiornis rufa*), CLPI (*Columba picazuro*), COMA (*C. maculosa*), COME (*Colaptes melanolaimus*), COPI (*Columbina picui*), DRBR (*Drymornis bridgesii*), DRSC (*Dryocopus schulzi*), EMAU (*Empidonomus aurantioatrocristatus*), LEAN (*Lepidocolaptes angustirostris*), LEVE (*Leptotila verreauxi*), MYMA (*Myiodynastes maculatus*), MYMO (*Myiopsitta monachus*), MYTY (*Myiarchus tyrannulus*), PAPO (*Pachyramphus polychopterus*), PIMI (*Picoides mixtus*), SUSU (*Suiriri suiriri*), XIMA (*Xiphocolaptes major*), and ZEAU (*Zenaida auriculata*).

calizations (Bibby et al. 1992, Ralph et al. 1996); consequently, detection ability can vary significantly among observers (Rappole et al. 1998, Nichols et al. 2000). Similarly, species differ in characteristics that affect detection and identification (Nichols et al. 2000, Wang and Finch 2002), thereby increasing the variability of results.

Mist-net captures may reflect differences in activity, whereas point counts more likely reflect variation in abundance (Remsen and Good 1996). In some cases, however, relative abundances obtained by the two methods are similar (Wang and Finch 2002). In Chaco forest, we believe that mist-net captures reflected bird movements, whereas other activities (e.g., nesting, courtship, displays, and territorial singing) were more likely to be detected during point counts. Depending on the layer where activities occur, the probability of detection can vary greatly between methods (Blake and Loiselle 2000, 2001). For example, woodcreepers were detected more frequently in the canopy with point counts, but a larger number were captured with mist nets in the understory, where birds move from trunk to trunk. In contrast, most woodpeckers were only detected during point counts, as they tended to move between treetops above our canopy nets. These patterns are clear in the DCAs. The point-count DCA remained similar, even when we repeated the analysis with the same number of replicates as that of mist nets, selected at random. The poor explanatory power of the mist-net DCA was likely due to few or no captures of birds from some guilds (i.e., arboreal granivores, carnivores, long-flight insect-hunters).

The utility of point counts and mist nets is influenced by vegetation structure (Blake and Loiselle 2000, 2001; Wang and Finch 2002): the relative contribution of each method may vary in different environments. In tall forests, canopy birds are poorly represented by both understory mist nets and point counts (Blake and Loiselle 2001). In Chaco forests, where canopies are lower, the point-count census technique was adequate and the contribution of canopy nets was less significant. Only understory mist nets captured species not detected on point counts. Nonetheless, the usual disadvantage of underestimating canopy birds during mist-netting efforts was at least partially avoided by using canopy nets (e.g., canopy nets accounted for higher proportions of frugivores). Finally, comparisons of captures and counts among layers provided evidence of movement between resource patches.

## ACKNOWLEDGMENTS

This study was supported by Project 997 (EJD), Project 752 (SMC), and a graduate fellowship (EJD), all from the Research Council of Salta National University (CIUNSa). C. Trucco, A. Tálamo, C. Bracamonte, P. Cardozo, J. Chalub, and J. Gato proffered invaluable collaboration during fieldwork. M. Fabrezi provided a vehicle for most of the field trips. We are very grateful to ''Boni'' Pérez and family for their hospitality and assistance in the field. Thanks to A. Tálamo for advice on the multivariate analyses. A. L. Sureda and M. Cassels translated the Spanish version of the manuscript, and C. Trucco and D. Vázquez offered helpful critiques. We are very grateful to J. G. Blake, who gave us advice at an early stage of this research, and to J. López de Casenave, J. H. Rappole, and K. Cockle for their insightful critiques of the English version of the manuscript. We also thank J. G. Blake, B. Poulin, and an anonymous reviewer, whose suggestions improved earlier versions of this manuscript.

## LITERATURE CITED

ANDERSON, S. H. AND H. H. SHUGART, JR. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55:828–837.

BIBBY, C. J., N. D. BURGESS, AND D. A. HILL. 1992. Bird census techniques. Academic Press, London, United Kingdom.

BLAKE, J. G. 1992. Temporal variation in point counts of birds in a lowland wet forest in Costa Rica. Condor 94:265–275.

BLAKE, J. G. AND B. A. LOISELLE. 2000. Diversity of birds along an elevational gradient in the Cordillera Central, Costa Rica. Auk 117:663–686.

BLAKE, J. G. AND B. A. LOISELLE. 2001. Bird assemblages in second-growth and old-growth forests, Costa Rica: perspectives from mist nets and point counts. Auk 118:304–326.

BLAKE, J. G. AND M. ROUGÈS. 1997. Variation in captures of understory birds in El Rey National Park, northwestern Argentina. Ornitología Neotropical 8:185–193.

CAZIANI, S. M. 1996. Interacción plantas-aves dispersoras de semillas en un Bosque Chaqueño semiárido. Ph.D. dissertation, Universidad de Buenos Aires, Argentina.

CODESIDO, M. AND D. N. BILENCA. 2000. Comparación de los métodos de transecta de faja y de conteo de puntos de radio fijo en una comunidad de aves del bosque semiárido santiagueño. El Hornero 15: 85–91.

GARDALI, T., G. BALLARD, N. NUR, AND G. R. GEUPEL. 2000. Demography of a declining population of Warbling Vireos in coastal California. Condor 102:601–609.

GAUCH, H. G. 1982. Multivariate analysis in community ecology. Cambridge University Press, New York.

GOTELLI, N. J. AND G. L. ENTSMINGER. 2002. Ecosim: null models software for ecology, ver. 7. Acquired Intelligence, Inc. & Kesey-Bear, Burlington, Vermont.

GRAM, W. K. AND J. FAABORG. 1997. The distribution of Neotropical migrant birds wintering in the El Cielo Biosphere Reserve, Tamaulipas, Mexico. Condor 99:658–670.

HERRERA, C. M. 1978. Ecological correlates of residence and non-residence in a Mediterranean passerine bird community. Journal of Animal Ecology 47:871–890.

HUMPHREY, P. S., D. BRIDGE, AND T. E. LOVEJOY. 1968. A technique for mist-netting in the forest canopy. Bird Banding 39:43–50.

JAMES, F. C. AND S. RATHBUN. 1981. Rarefaction, relative abundance, and diversity of avian communities. Auk 98:785–800.

KARR, J. R. 1976. Within- and between-habitat avian diversity in African and Neotropical lowland habitats. Ecological Monographs 46:457–481.

KARR, J. R. 1977. Ecological correlates of rarity in a tropical forest bird community. Auk 94:240–247.

KARR, J. R. 1981. Surveying birds with mist nets. Studies in Avian Biology 6:62–67.

LOISELLE, B. A. 1987. Migrant abundance in a Costa Rican lowland forest canopy. Journal of Tropical Ecology 3:163–168.

LOPEZ DE CASENAVE, J., J. P. PELOTTO, S. M. CAZIANI, M. MERMOZ, AND J. PROTOMASTRO. 1998. Responses of avian assemblages to a natural edge in a Chaco semiarid forest in Argentina. Auk 115: 425–435.

LOVEJOY, T. E. 1974. Bird diversity and abundance in Amazon forest communities. Living Bird 13:127–191.

MASON, D. 1996. Responses of Venezuelan understory birds to selective logging, enrichment strips, and vine cutting. Biotropica 28:296–309.

MCCUNE, B. AND M. J. MEFFORD. 1997. PC-ORD: multivariate analysis of ecological data, ver. 3.0. MjM Software Design, Gleneden Beach, Oregon.

MEYERS, J. M. AND K. L. PARDIECK. 1993. Evaluation of three elevated mist-net systems for sampling birds. Journal of Field Ornithology 64:270–277.

MILLS, T. R., M. A. RUMBLE, AND L. D. FLAKE. 2000. Habitats of birds in ponderosa pine and aspen/birch forest in the Black Hills, South Dakota. Journal of Field Ornithology 71:187–206.

NICHOLS, J. D., J. E. HINES, J. R. SAUER, F. W. FALLON, J. E. FALLON, AND P. J. HEGLUND. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393–408.

POULIN, B., G. LEFEVBRE, AND P. PILARD. 2000. Quantifying the breeding assemblage of reedbed passerines with mist-net and point-count surveys. Journal of Field Ornithology 71:443–454.

PROHASKA, F. 1959. El polo de calor de América del Sur. Instituto Nacional de Tecnología Agropecuaria, IDIA 141:27–30.

PROTOMASTRO, J. J. 1988. Fenología y mecanismos de interacción en el bosque de quebracho colorado, blanco, y mistol. Ph.D. dissertation, Universidad de Buenos Aires, Argentina.

RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, D. F. DESANTE, AND B. MILÁ. 1996. Manual de métodos de campo para el monitoreo de aves terrestres. General Technical Report PSW-GTR-159, USDA Forest Service, Pacific Southwest Research Station, Albany, California.

RALPH, C. J., J. R. SAUER, AND S. DROEGE. 1995. Monitoring bird populations by point counts: standards and applications. General Technical Report PSW-GTR-149, USDA Forest Service, Pacific Southwest Research Station, Albany, California.

RAPPOLE, J. H., K. WINKER, AND G. V. N. POWELL. 1998. Migratory bird habitat use in southern Mexico: mist nets versus point counts. Journal of Field Ornithology 69:635–643.

REMSEN, J. V., JR., AND D. A. GOOD. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. Auk 113:381–398.

RESTREPO, C. AND N. GÓMEZ. 1998. Responses of understory birds to anthropogenic edges in a Neotropical montane forest. Ecological Applications 8:170–183.

SCHEWSKE, D. W. AND N. BROKAW. 1981. Treefalls and the distribution of understory birds in a tropical forest. Ecology 62:938–945.

SCHIECK, J. 1997. Biased detection of bird vocalizations affects comparisons of bird abundance among forested habitats. Condor 99:179–190.

TÁLAMO, A. AND S. M. CAZIANI. 2003. Variation in woody vegetation among sites with different disturbance histories in the Argentine Chaco. Forest Ecology and Management 184:79–92.

TERBORGH, J., S. K. ROBINSON, T. A. PARKER, III, C. A. MUNN, AND N. PIERPONT. 1990. Structure and organization of an Amazonian forest bird community. Ecological Monographs 60:213–238.

THOMPSON, I. D., H. A. HOGAN, AND W. A. MONTEVECCHI. 1999. Avian communities of mature balsam fir forests in Newfoundland: age-dependence and implications for timber harvesting. Condor 101:311–323.

VERNER, J. AND K. L. PURCELL. 1999. Fluctuating populations of House Wrens and Bewick's Wrens in foothills of the western Sierra Nevada of California. Condor 101:219–229.

VON ENDE, C. N. 1993. Repeated-measures analysis: growth and other time-dependent measures. Pages 113–137 *in* Design and analysis of ecological experiments (S. M. Scheiner and J. Gurevitch, Eds.). Chapman and Hall, New York.

WALLACE, G. E., H. G. ALONSO, M. K. MCNICHOLL, D. R. BATISTA, R. O. PRIETO, A. L. SOSA, B. S. ORIA, AND E. A. H. WALLACE. 1996. Winter survey of forest-dwelling Neotropical migrant and resident birds in three regions of Cuba. Condor 98:745–768.

WANG, Y. AND D. M. FINCH. 2002. Consistency of mist netting and point counts in assessing landbird species richness and relative abundance during migrations. Condor 104:59–72.

WEGE, D. C. AND A. J. LONG. 1995. Key areas for threatened birds in the Neotropics. BirdLife Conservation Series, no. 5, BirdLife International, Cambridge, United Kingdom.

WHITMAN, A. A., J. M. HAGAN, III, AND N. V. L. BROKAW. 1997. A comparison of two bird survey techniques used in a subtropical forest. Condor 99: 955–965.

WINKLER, H. AND M. PRELEUTHNER. 2001. Behavior and ecology of birds in tropical rain forest canopies. Plant Ecology 153:193–202.