Tropical Ecology **52**(1): 25-33, 2011 ISSN 0564-3295

www.tropecol.com

Avian diversity and relative abundance in a restinga forest of Sao Paulo, Brazil

FABIO ROSSANO DARIO[1*] & MARIA CRISTINA VEIGA DE VINCENZO[2]

[1]*Instituto de Pesquisas e Estudos da Vida Silvestre, Brazil*
[2]*Agência de Inovação USP, Brazil*

Abstract: The forests along Brazil's Atlantic coast have undergone extensive transformation from clearing for agriculture and urban expansion. In this study we describe the avian community in a coastal restinga forest near the city of Ubatuba, northern coast of the state of São Paulo in southeastern Brazil. We used point counts to characterize the avifauna. During 36 hours of observation we recorded 114 species of birds distributed among 23 families. We calculated point abundance, frequency of occurrence and Kendeigh index for each species. Similarly, community metrics [diversity (H´ = 3.91) and equitability (E = 0.82)] were obtained for the avifauna in our study site. Omnivores and insectivores were more abundant, with 45 and 35 species respectively. Our results show that despite being a secondary forest the study area was characterized by a diverse avian community.

Resumen: Los bosques ubicados a lo largo de la costa atlántica de Brasil han sufrido una transformación extensa debido al aclareo del bosque para la agricultura y la expansión urbana. En este estudio describimos la comunidad de avifauna en un bosque costero de restinga cerca de la ciudad de Ubatuba, en la costa norte del estado de San Pablo, sureste de Brasil. Usamos conteos puntuales para caracterizar a la avifauna. Durante 36 horas de observación registramos 114 especies de aves distribuidas en 23 familias. Para cada especie calculamos la abundancia puntual, la frecuencia de aparición y el índice de Kendeigh. Además, se obtuvieron métricas de la comunidad [diversidad [(H´ = 3.91) y equitatividad (E = 0.82)] para la avifauna en nuestro sitio de estudio. Los omnívoros y los insectívoros fueron los gremios más abundantes, con 45 y 35 especies, respectivamente. Nuestros resultados muestran que a pesar de tratarse de un bosque secundario, el área de estudio estuvo caracterizada por una comunidad de avifauna diversa.

Resumo: As florestas ao longo da costa Atlântica do Brasil sofreram transformações extensivas resultantes dos abates para a agricultura e a expansão urbana. Neste estudo descrevemos a comunidade avícola numa floresta de restinga costeira perto da cidade de Ubatuba, na faixa costeira norte do estado de São Paulo, no sudeste do Brasil. Para caracterizar a avifauna usámos contagens por pontos. Durante 36 horas de observação registaram-se 114 espécies de aves distribuídas por 23 famílias. Calculou-se a abundância por ponto, a frequência de ocorrência e oíndice de Kendeigh para cada espécie. Da mesma forma, obtiveram-se as métricas da diversidade da comunidade [(H´ = 3,91) e semelhança (E = 0,82)] para a avifauna no local de estudo. As espécies omnívoras e insectívoras foram as mais abundantes, com 45 e 35 espécies, respectivamente. Os nossos resultados mostram que apesar de se tratar de uma floresta secundária a área de estudo foi caracterizada por uma comunidade avícola diversificada.

* *Corresponding Author*; e-mail: fabiorossano@hotmail.com; *Present Address*: Rua Leonardo Mota, 66 apt. 184, Vila Indiana, São Paulo - SP - Brazil, CEP: 05586-090

Key words: Avifauna, birds, Brazil, restinga forest.

Introduction

The Atlantic forest biome of Brazil stretches from the northern state of Rio Grande do Norte south to Rio Grande do Sul. It ranges inland to eastern Paraguay and the province of Misiones in northeastern Argentina, and narrowly along the coast into Uruguay (Duffy 2007). The Atlantic forest is a global biodiversity hotspot, originally covering over 1 million km^2 and is the most disturbed of all Brazilian hotspots. This important biome harbors a high diversity of species, with several endemic and threatened species (Myers *et al.* 2000). Deforestation dates to colonial times from agriculture and urban settlements (Dean 1995).

The Atlantic rainforest has an extremely diverse and unique mix of vegetation and forest types. Restinga is a coastal ecosystem which form on sandy, acidic, and nutrient-poor soils, and is characterized by medium sized trees and shrubs adapted to the dry and nutrient-poor conditions found there (Araújo 1992). The restinga consist of three well-defined forest enclaves distributed from northeastern to southeastern Brazil (Lacerda *et al.* 1984). Restinga forests vary from shrub vegetation to 15 m tall forests, which are distributed over soil mosaics and gradients from the coastal zone inland (Silva 1999; Sacramento 2000).

The arboreal restinga occurs between the "nhundu" and the Atlantic coastal forest, and it can reach the Atlantic Slope in places where the coastal plain is overly narrow, as it happens in Ubatuba, in the state of São Paulo. This kind of restinga is formed from soggy soils, with sparse trees varying in average height between 10 and 15 m. The thick understorey is overgrown by bushes and trees covered with various epiphytes (Sigrist 2006).

The Atlantic rainforest has spectacular bird diversity, with over 930 species, about 15 percent of which are found nowhere else (Duffy 2007). This avifauna is a highly endangered community: 68 % of the species are rare and there are 23 endemic genera (Goerck 1997). Because most of the region's forests have been cleared during 500 years of exploitation, many species are now threatened, and future extinctions seem inevitable, considering that only 7 % of the original forest remains (Brooks *et al.* 1999; Tabarelli *et al.* 2005). Due to the paucity of information regarding avian abundance estimates in Restinga, the main objective of our study was to characterize the groups of birds that occurs in this important ecosystem.

Material and methods

Study site

The study was carried out in the city of Ubatuba (23° 23' S, 44° 58' W) during 2005. Elevation ranged from 0-12 meters a.s.l. and annual average rainfall was over 2,200 mm, concentrated in the spring and summer. Ambient temperature averaged 21.9 °C, and ranged from 17.0 °C - 26.8 °C. Vegetation structure was dominated by arboreal restinga (transition between coastal scrub and coastal forest). The area was dominated by 40-year old secondary forest. The overstorey was characterized by crowns of large-sized trees varying in average height between 8 and 12 m, mean trunk diameter was 12 cm. Important species recorded included: *Alchornea triplinervia*, *Cytharexyllum myrianthum*, *Inga laurina*, *Ocotea pulchella*, *Ficus organensis*, *Cabralea canjerana*, *Calophyllum brasiliensis*, *Hirtella hebeclada*, *Rollinia silvatica*, *Campomanesia xanthocarpa*, *Casearia sylvestris*, *Guatteria australis, Guapira opposita*, *Zanthoxylum rhoifolium*, *Tibouchina mutabilis*, *Nectandra rigida*, *Rapanea ferruginea, Cecropia pachystachya*, *Tapirira guianensis*, and small patches of Jussara palm (*Euterpe edulis*). Most of these trees produced fruit used by local wildlife (Frisch & Frisch 2005; Galetti 1996; Scherer *et al.* 2007). Extraction of Jussara palm continues to be a frequent cause of habitat disturbance in this region (Galetti & Aleixo 1998; Marcos & Matos 2003).

Understorey vegetation was characterized by shrubs (0.80 m - 5 m tall) and dominated by *Eugenia uniflora, Trema micrantha*, and *Schinus terebinthifolius*. Saplings of trees in the families Melastomataceae, Euphorbiaceae, Rubiaceae, Fabaceae, Caesalpiniaceae and Myrtaceae were common. Trees sheltered a high number of epiphytes including bromeliads (*Quesnelia arvensis*), orchids (*Epidendrun* spp), aroids (*Monstera adansoni*), cacti (*Rhipsalis* spp), mosses, lichens and vines. Marsh vegetation appeared on poorly drained soils and

was dominated by *Hedychium coronarium* and *Typha dominguensis*. These areas periodically flooded, providing habitat for a large variety of wading birds (Sigrist 2006).

Bird surveys

We used point counts to register presence and abundance of bird species (Blondel *et al*. 1970). Location of points was randomly selected and was representative of the area. Points were located at least 200 meters apart to avoid double-counting highly vocal species (Vielliard 2000). We conducted counts during the first hours after dawn and during twilight. Counts were completed in 12 days during all four seasons of 2005 (a total of 36 hours distributed in 108 samples of 20 minutes). Point count duration was 20 minutes, as proposed for tropical environments (Vielliard 2000). Our study site, a forest tract (≤ 10 hectares) was part of a continuous forest connected to Serra do Mar State Park. Points were located in both edge and interior sections of the forest. Birds were identified by sight and sound (mostly). Birds who overflew the point were not included in the data. For bird identification and taxonomic status we used Schauensee (1982), Sibley & Monroe Jr. (1990), and Sick (1997).

The predominant diet for each bird species was obtained from literature sources (Dubs 1992; Sick 1997; Sigrist 2006 and Willis 1979). For each species we calculated Point Abundance Index (PAI), by dividing the number of detections for each species by the total number of points sampled (Blondel *et al*. 1970). We also calculated Frequency of Occurrence according to Linsdale (1928), and Kendeigh Index (Kendeigh 1944) which allows comparisons of relative abundance among different species or inside the same population. To characterize bird community metrics, we obtained Shannon-Weaver diversity index (H´) and equitability (Pielou 1966; Tramer 1969).

Results and discussion

A total of 114 bird species were recorded in our study (Appendix Table 1). Bird species detected were distributed among 23 families. The total number of detections was 2,502 and the density of birds in the area was 69.50 individuals/observation-hour. The most representative order was Passeriformes with 73 species which accounted for 63 % of all species recorded.

Omnivores included 45 species and 60.1 % of detections. Also, insectivores and nectar-feeders, were represented by 35 (25.2 % detections) and 13 species (8.0 % detections). Among the 12 species of hummingbirds observed visiting flowers, *Phaethornis eurynome*, *Phaethornis pretrei* and *Amazilia fimbriata* were most common (Table 1). The avian community in our study were similar to other Atlantic forest areas studied (Almeida 1982; Anjos *et al*. 2007; Antunes 2007; Piratelli *et al*. 2005; Willis 1979) with a predominance of omnivores and insectivores species.

The most abundant species (Appendix Table 1) were *Tangara seledon*, *Tangara cyanocephala*, *Drymophila squamata*, *Thraupis palmarum*, *Ramphocelus bresilius* and *Thraupis sayaca*, all omnivorous species, except *Drymophila squamata* (insectivore). Abundance index values (PAI) showed our study site had a large number of species with low PAI and few species with intermediate to high PAI compared to the pattern observed in other surveys (Aleixo & Vielliard 1995; Dario 2008; Lyra-Neves *et al*. 2004). The PAI varied from 0.0093 (one contact) in seven species to 2.7222 (294 contacts) for *Tangara seledon*, an abundant species found along Atlantic Rainforest slopes. It lives in large monospecific groups in association with other species in the genus *Tangara*, especially *T. cyanocephala*, and other tanager species in the genera *Tachyphonus*, *Dacnis* and *Euphonia*. The most abundant according in our study was *Tangara cyanocephala* (268 contacts, PAI = 2.4815). Fig. 1 includes ordination of PAI values in decreasing order.

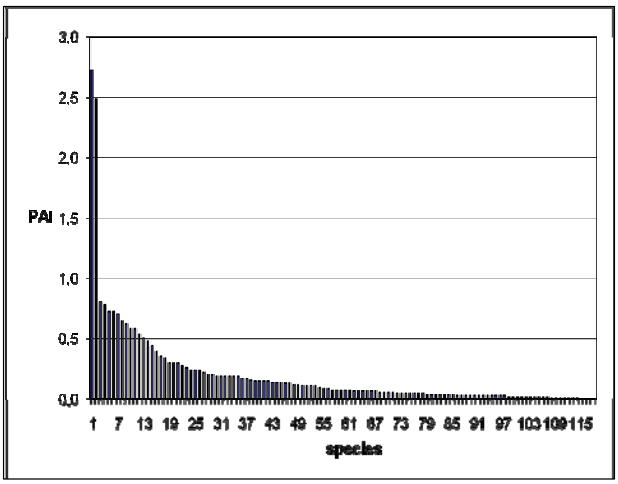

Fig. 1. Ordination of Point Abundance Index (PAI) in decreasing order of the species registered in arboreal restinga, Ubatuba-Brazil.

Among the least abundant species in the study area were small frugivores, represented by six species (Appendix Table 1). Despite the reduced abundance of frugivores such as *Penelope obscura* and *Procnias nudicollis*, and understorey species such as *Turdus albicollis*, *Leptotila verreauxi*, *Claravis pretiosa* and some antshrike species (family Thamnophilidae) the study area represented relatively well conserved, albeit secondary forest. Others signs of adequate habitat conditions included the occurrence of mixed-species flocks (Stotz 1993) and army-ant swarm following birds (e.g., *Pyriglena leucoptera*). However, many of the species registered in our study were edge species (e.g., *Pitangus sulphuratus*, *Tyrannus melancholicus*, *Thraupis sayaca*, *Zonotrichia capensis*, *Sporophila caerulescens*, and *Turdus rufuventris*).

We recorded a number of wetland species (e.g., *Tigrisoma lineatum*, *Pardirallus nigricans*, and *Aramides saracura*) associated with swampy vegetation and flooded areas with cattails. We observed several mixed-species flocks composed of large numbers of insectivore and omnivore species such as *Tangara seledon*, *Tangara cyanocephala*, *Thraupis sayaca*, *Ramphocelus bresilius*, *Attila rufus*, *Habia rubica, Sittasomus griseicapillus,* and *Tachyphonus cristatus*. Frequency and structure of mixed-species flocks also suggests habitat conditions at the study area were adequate for many common Atlantic Rainforest bird species according to Ghizoni Jr & Azevedo (2006).

Mixed-species flocks are common in many tropical forests and have been well described in the Neotropics. Mixed-species flocking birds may increase foraging efficiency (Wilson 1975) and protection from predation (Thiollay 1999). Mixed-species flocks in tropical forests are maintained throughout the annual cycle despite seasonal differences in resource availability, breeding seasons, and ecological requirements of individual species (Develey & Peres 2000). In our study seasonal variation in flock structure and composition may have been affected by the breeding seasons of different core and attendant species, as well as the availability of food resources. The observed richness of mixed-species flocks may have been related to both forest structure and available fruit and arthropod resources of the understorey, according to Stotz (1993).

Our study area was characterized by high species diversity. The Shannon-Weaver diversity index for our study area was 3.91. Our results were similar to those reported by Allegrini (1997) and Dario *et al*. (2002) in different areas of the State of São Paulo. Allegrini (1997) obtained a value of 3.68 in a site characterized by more mature secondary forest, a value of 3.95 in medium secondary forest, and 3.45 in early sucessional forest. Dario *et al*. (2002), analyzed three forest fragments (47, 26 and 4 hectares) and obtained diversity index values of 3.77, 3.68 and 3.98, respectively. Equitability was high (E = 0.82), suggesting the number of species registered in our study site represented the maximum capacity the area can shelter (Magurran 1988).

The size of the area and the vegetation structure were reflected in the high diversity of bird species recorded. However, the connectivity with the Serra do Mar State Park has been influencing directly in the diversity of species of the avifauna registered. The great abundance of omnivores birds may be directly related to the abundant fruit resources. These results suggest the sensitivities of bird species to vegetation are associated with their dependence on a fruit diet (Hasui *et al*. 2007).

The occurrence of many species commonly found in human altered habitats reflects the continuing degradation of these coastal restinga forests as more and more of these sites disappear. Some changes in vegetation structure and composition caused by deforestation may disrupt those interactions and change bird community composition (Canterbury *et al*. 2000; Gabbe *et al*. 2002). The conservation, restoration, and ecological studies of Restinga forests represent important actions for conservation in the Atlantic Rainforest.

References

Aleixo, A. & J. M. E. Vielliard. 1995. Composição e dinâmica da avifauna da Mata de Santa Genebra, Campinas, São Paulo, Brasil. *Revista Brasileira de Zoologia* **12**: 493-511.

Allegrini, M. F. 1997. *Avifauna Como Possível Indicador Biológico dos Estádios de Regeneração da Mata Atlântica.* M.Sc. Thesis. Universidade de São Paulo, Brasil.

Almeida, A. F. 1982. Análise das categorias de nichos tróficos das aves de matas ciliares em Anhembi, Estado de São Paulo. *Silvicultura em São Paulo* **16**: 1787-1795.

Anjos, L., G. H. Volpato, E. V. Lopes, P. P. Serafini, F. Poletto & A. Aleixo. 2007. The importance of riparian forest for the maintenance of bird species riparian forest for bird richness in an Atlantic Forest remnant, southern Brazil. *Revista Brasileira de Zoologia* **24**: 1078-1086.

Antunes, A. Z. 2007. Riqueza e dinâmica de aves endêmicas da Mata Atlântica em um fragmento de floresta estacional semidecidual no sudeste do Brasil. *Revista Brasileira de Ornitologia* **15**: 61-68.

Araújo, D. S. D. 1992. Vegetation types of sandy coastal plains of tropical Brazil: a first approximation. pp. 337-347. *In*: U. Seeliger (ed.) C*oastal Plant Communities of Latin America*. Academic Press, San Diego.

Blondel, J., C. Ferry & B. Frochot. 1970. La méthode des indices ponctuels d'abondance (I.P.A.) ou des relevés d'avifaune par "stations d'écoute". *Alauda* **38**: 55-71.

Brooks, T., J. A. Tobias & A. Balmford. 1999. Deforestation and bird extinctions in the Atlantic Forest. *Animal Conservation* **2**: 211-222.

Canterbury, G. E., T. E. Martin, D. R. Petit, L. J. Petit & D. F. Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. *Conservation Biology* **14**: 544-558.

Dario, F. R., M. C. V. De Vincenzo & A. F. Almeida. 2002. Avifauna em fragmentos da Mata Atlântica. *Ciência Rural* **32**: 989-996.

Dario, F. R. 2008. Estrutura trófica da avifauna em fragmentos florestais na Amazônia Oriental. *Conscientiae Saúde* **7**: 169-179.

Dean, W. B. 1995. *With Broadax and Firebrand: the Destruction of the Brazilian Atlantic Fores*t. University of California Press, Berkeley.

Develey, P. F. & C. A. Peres. 2000. Resource seasonality and the structure of mixed species bird flocks in a coastal Atlantic forest of southeastern Brazil. *Journal of Tropical Ecology* **16**: 33-53.

Dubs, B. 1992. *Birds of Southwestern Brazil*. Betrona-Verlag, Küsnacht.

Duffy, J. E. 2007. Biological diversity in the Atlantic forest. *In*: J. Cutler (ed.) *Encyclopedia of Earth*. Cleveland. (Washington D.C. : Environmental Information Coalition, National Council for Science and the Environment). [First published in Encyclopedia of Earth May 22, 2007; last revised August 22, 2008; Retrieved February 15, 2010] <http:// www.eoearth.org/article/Biological diversity in the Atlantic Forest>

Frisch, J. D. & C. D. Frisch. 2005. *Aves Brasileiras e Plantas Que as Atraem*. Dalgas Ecoltec, São Paulo.

Gabbe, A. P., S. K. Robinson & J. D. Brawn. 2002. Tree-species preferences of foraging insectivorous birds: implications for floodplain forest restoration. *Conservation Biology* **16**: 462-470.

Galetti, M. 1996. *Fruit and Frugivores in a Brasilian Atlantic Forest*. Ph.D. Dissertation, University of Cambridge, England.

Galetti, M. & A. Aleixo. 1998. Effects of palm heart harvesting on avian frugivores in Atlantic rain forest of Brazil. *Journal of Applied Ecology* **35**: 286-293.

Ghizoni Jr., I. & M. A. G. Azevedo. 2006. Composição de bandos mistos de aves florestais de sub-bosque em áreas de encosta e planície da Floresta Atlântica de Santa Catarina, sul do Brasil. *Biotemas* **19**: 47-53.

Goerck, J. M. 1997. Patterns of rarity in the birds of the Atlantic forest of Brazil. *Conservation Biology* **11**: 112-118.

Hasui, E., V. S. M. Gomes & W. R. Silva. 2007. Effects of vegetation traits on habitat preferences of frugivorous birds in Atlantic rainforest. *Biotropica* **39**: 502-509.

Kendeigh, S. C. 1944. Measurement of bird populations. *Ecological Monographs* **14**: 69-106.

Lacerda, L. D., D. S. D. Araújo, R. Cerqueira & B. Turco (org.). 1984. *Restingas: Origem, Estrutura, Processos*. Universidade Federal Fluminense, Rio de Janeiro.

Linsdale, J. 1928. A method of showing relative frequency of occurrence of birds. *The Condor* **30**: 180-184.

Lyra-Neves, R. M., M. M. Dias, S. M. Azevedo Jr, W. R. Telino Jr. & M. E. L. Larrazábal. 2004. Comunidade de aves da Reserva Estadual de Gurjaú, Pernambuco, Brasil. *Revista Brasileira de Zoologia* **21**: 581-592.

Magurran, A. E. 1988. *Ecological Diversity and its Measurement*. London, Croom Helm.

Marcos, C. S. & D. M. S. Matos. 2003. Estrutura de populações de palmiteiro (*Euterpe edulis* Mart.) em áreas com diferentes graus de impactação na floresta da Tijuca, RJ. *Floresta e Ambiente* **10**: 27-37.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* **403**: 853-858.

Pielou, E. C. 1966. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* **13**: 131-144.

Piratelli, A., V. A. Andrade & M. Lima Filho. 2005. Aves de fragmentos florestais em área de cultivo de canadeaçúcar no sudeste do Brasil. *Iheringia* **95**: 217-222.

Sacramento, A. C. S. 2000. *Levantamento Florístico da Restinga da Praia do Paiva - Ponte dos Carvalhos, Cabo de Santo Agostinho, Pernambuco*. M.Sc. Thesis. Universidade Federal Rural de Pernambuco, Brasil.

Schauensee, R. M. 1982. *A Guide to the Birds of South America*. S.L. Intercollegiate Press.

Scherer, A., F. Maraschin-Silva & L. R. M. Baptista. 2007. Padrões de interações mutualísticas entre espécies arbóreas e aves frugívoras em uma comunidade de Restinga no Parque Estadual de Itapuã, RS, Brasil. *Acta Botanica Brasilica* **21**: 203-212.

Sibley, C. G. & B. L. Monroe Jr. 1990. *Distribution and Taxonomy of Birds of the World*: Yale University

Press, New Haven.

Sick, H. 1997. *Ornitologia Brasileira*. Nova Fronteira, Rio de Janeiro.

Sigrist, T. 2006. *Birds of Brazil: An Artistic View*. São Paulo.

Silva, S. M. 1999. Diagnóstico das restingas do Brasil. pp. 161-176. *In*: Fundação Bio Rio (ed.) *Workshop Avaliação e Ações Prioritárias Para a Conservação da Biodiversidade da Zona Costeira*. Ilhéus.

Stotz, D. F. 1993. Geographic variation in species composition of mixed species flocks in lowland humid forest in Brazil. *Papéis Avulsos de Zoologia* **38**: 61-75.

Tabarelli, M., L. P. Pinto, J. M. C. Silva, M. Hirota & L. Bedê. 2005. Challenges and opportunities for biodiversity conservation in the Brazilian Atlantic forest. *Conservation Biology* **19**: 695-700.

Thiollay, J. M. 1999. Frequency of mixed species flocking in tropical forest birds and correlates of predation risk: an intertropical comparison. *Journal of Avian Biology* **30**: 282-294.

Tramer, E. J. 1969. Bird species diversity: components of Shannon's formula. *Ecological Monographs* **50**: 927-929.

Vielliard, J. M. E. 2000. Bird community as an indicator of biodiversity: results from quantitative surveys in Brazil. *Anais da Academia Brasileira de Ciências* **72**: 323-330.

Willis, E. O. 1979. The compositions of avian communities in remanescents woodlots in southern Brazil. *Papéis Avulsos de Zoologia* **33**: 1-25.

Wilson, E. O. 1975. *Sociobiology: the New Synthesis*. Harvard University Press, Cambridge.

Appendix Table 1. Point Abundance Index (PAI), Frequency of Occurrence (FO) and Kendeigh Index (KI) of each bird species recorded in arboreal restinga, Ubatuba-Brazil. Families and species are presented in the taxonomic order of Sibley & Monroe (1990). Predominant diet (PD): Carnivore (C), Frugivore (F), Granivore (G), Insectivore (I), Nectarivore (N), and Omnivore (O).

Families/*Species*	PD	PAI	FO	KI
Cracidae				
Penelope obscura	F	0.0185	0.93	1.36
Picidae				
Picumnus cirratus (mix)	I	0.2407	21.30	4.91
Melanerpes flavifrons	I	0.0370	3.70	1.92
Celeus flavescens	I	0.2222	18.52	4.71
Dryocopus lineatus	I	0.0741	5.56	2.72
Ramphastidae				
Ramphastos vitellinus	F	0.0370	0.93	1.92
Cerylidae				
Chloroceryle americana (rip)	C	0.0463	4.63	2.15
Coccyzydae				
Piaya cayana	I	0.1111	11.11	3.33
Psittacidae				
Pyrrhura frontalis	F	0.0278	0.93	1.67
Forpus xanthopterygius	F	0.4815	10.19	6.94
Pionus maximiliani	F	0.0278	0.93	1.67
Trochilidae				
Glaucis hirsutus	N	0.0741	7.41	2.72
Phaethornis eurynome (rip)	N	0.3426	29.63	5.85
Phaethornis squalidus	N	0.0370	3.70	1.92
Phaethornis pretrei	N	0.1852	16.67	4.30

Contd...

Appendix Table 1. Continued.

Families/*Species*	PD	PAI	FO	KI
Phaethornis ruber	N	0.0278	2.78	1.67
Ramphodon naevius	N	0.0278	2.78	1.67
Florisuga fusca	N	0.0093	0.93	0.96
Chlorostilbon aureoventris	N	0.0648	6.48	2.55
Thalurania glaucopis	N	0.1204	10.19	3.47
Amazilia versicolor	N	0.0741	7.41	2.72
Amazilia fimbriata	N	0.1667	16.67	4.08
Aphantochroa cirrochloris	N	0.1481	13.89	3.85
Tytonidae				
Tyto alba	C	0.0093	0.93	0.96
Columbidae				
Claravis pretiosa (gro)	O	0.0093	0.93	0.96
Leptotila verreauxi	O	0.0648	6.48	2.55
Rallidae				
Laterallus viridis (wet)	O	0.0278	2.78	1.67
Aramides saracura (wet)	O	0.1481	4.63	3.85
Pardirallus nigricans (wet)	O	0.0463	2.78	2.15
Accipitridae				
Leucopternis polionotus	C	0.0185	1.85	1.36
Buteogallus urubitinga	C	0.0093	0.93	0.96
Buteo magnirostris	C	0.0648	6.48	2.55
Buteo brachyurus	C	0.0093	0.93	0.96
Buteo albicaudatus	C	0.0185	1.85	1.36
Falconidae				
Polyborus plancus (gro)	C	0.0093	0.93	0.96
Milvago chimachima (gro)	C	0.0556	5.56	2.36
Ardeidae				
Egretta thula (rip)	C	0.0370	3.70	1.92
Butorides striata (wet)	C	0.0278	2.78	1.67
Tigrisoma lineatum (wet)	C	0.0185	1.85	1.36
Tyrannidae				
Hemitriccus diops	I	0.1852	15.74	4.30
Todirostrum cinereum	I	0.1389	12.04	3.73
Camptostoma obsoletum	O	0.1296	10.19	3.60
Elaenia flavogaster	O	0.0556	4.63	2.36
Elaenia parvirostris	O	0.0185	1.85	1.36
Serpophaga subcristata	I	0.0370	3.70	1.92
Tolmomyias sulphurescens	O	0.0278	2.78	1.67
Myiophobus fasciatus	I	0.1481	12.04	3.85
Myiobius barbatus	I	0.2037	17.59	4.51
Lathrotriccus euleri (rip)	I	0.0463	3.70	2.15

Contd...

Appendix Table 1. Continued.

Families/*Species*	PD	PAI	FO	KI
Fluvicola nengeta (gro, wet)]	I	0.2963	18.52	5.44
Colonia colonus	I	0.0278	1.85	1.67
Attila rufus (mix)	O	0.0093	0.93	0.96
Myiarchus ferox (mix)	O	0.1296	11.11	3.60
Tyrannus melancholicus	O	0.1852	13.89	4.30
Tyrannus savana	I	0.0278	0.93	1.67
Megarynchus pitangua (rip)	O	0.0648	1.85	2.55
Myiodynastes maculatus (rip)	O	0.0556	5.56	2.36
Myiozetetes similis	O	0.1389	8.33	3.73
Pitangus sulphuratus (rip)	O	0.3889	29.63	6.24
Procnias nudicollis	F	0.0463	4.63	2.15
Chiroxiphia caudata	O	0.0463	1.85	2.15
Manacus manacus	O	0.5093	23.15	7.14
Thamnophilidae				
Mackenziaena severa	I	0.0463	4.63	2.15
Thamnophilus caerulescens	I	0.1204	10.19	3.47
Thamnophilus ruficapillus	I	0.1111	8.33	3.33
Dysithamus mentalis	I	0.1852	11.11	4.30
Myrmotherula unicolor	I	0.0926	7.41	3.04
Drymophila malura	I	0.5833	35.19	7.64
Drymophila squamata	I	0.8056	57.41	8.98
Pyriglena leucoptera (gro)	I	0.0185	1.85	1.36
Myrmeciza squamosa	I	0.1481	11.11	3.85
Furnariidae				
Synallaxis ruficapilla	I	0.0185	1.85	1.36
Philidor atricapillus	I	0.0185	1.85	1.36
Sittasomus griseicapillus (mix)	I	0.1389	12.96	3.73
Xiphorhynchus fuscus	I	0.0370	3.70	1.92
Formicariidae				
Formicarius colma (gro)	I	0.0278	2.78	1.67
Conopophagidae				
Conopophaga melanops	I	0.2963	25.93	5.44
Vireonidae				
Cyclarhis gujanensis (rip)	O	0.0185	1.85	1.36
Vireo olivaceus	O	0.0741	4.63	2.72
Muscicapidae				
Platycichla flavipes	O	0.1111	6.48	3.33
Turdus rufuventris (gro)	O	0.4444	39.81	6.67
Turdus amaurochalinus	O	0.1852	16.67	4.30
Turdus albicollis	O	0.0833	8.33	2.89
Certhiidae				

Contd...

Appendix Table 1. Continued.

Families/*Species*	PD	PAI	FO	KI
Troglodytes musculus (gro)	I	0.2407	20.37	4.91
Hirundinidae				
Progne tapera	I	0.0648	1.85	2.55
Notiochelidon cyanoleuca	I	0.2407	16.67	4.91
Fringillidae				
Zonotrichia capensis (gro)	G	0.2037	12.96	4.51
Parula pitiayumi	O	0.0648	4.63	2.55
Geothlypis aequinoctialis (wet)	I	0.0278	2.78	1.67
Basileuterus rivularis (gro, rip)	I	0.7222	41.67	8.50
Coereba flaveola	N	0.5833	35.19	7.64
Conirostrum speciosum (mix)	I	0.1111	7.41	3.33
Hemithraupis ruficapilla	O	0.1852	3.70	4.30
Tachyphonus cristatus (mix)	O	0.2593	19.44	5.09
Tachyphonus coronatus (mix)	O	0.6481	33.33	8.05
Habia rubica (mix)	O	0.0463	1.85	2.15
Ramphocelus bresilius (mix)	O	0.7222	31.48	8.50
Thraupis sayaca (mix)	O	0.7037	30.56	8.39
Thraupis ornata (mix)	O	0.3519	14.81	5.93
Thraupis palmarum (mix)	O	0.7778	37.04	8.82
Pipraeidea melanonota	O	0.0185	1.85	1.36
Euphonia violacea (mix)	O	0.0278	2.78	1.67
Euphonia pectoralis (mix)	O	0.5370	27.78	7.33
Tangara seledon (mix)	O	2.7222	53.70	16.50
Tangara cyanocephala (mix)	O	2.4815	50.00	15.75
Tangara cayana (mix)	O	0.2778	23.15	5.27
Dacnis nigripes	O	0.1574	12.96	3.97
Dacnis cayana (mix)	O	0.1667	13.89	4.08
Tersina viridis	O	0.0741	3.70	2.72
Volatinia jacarina	G	0.0556	2.78	2.36
Sporophila caerulescens	G	0.2963	7.41	5.44
Saltator similis	O	0.0370	3.70	1.92
Psarocolius decumanus	O	0.0833	1.85	2.89
Cacicus haemorrhous	O	0.6204	17.59	7.88

(rip) indicates species significantly related to the riparian vegetation; (wet) indicates wetland birds found in marshes and dense grassy fields; (gro) those related mainly on the ground; and (mix) those related accompanies mixed-species flocks through the forest understorey.