

SUPPLEMENTARY INFORMATION

Ornithology Research

Local management intensity and landscape forest cover affect bird community structure in shaded cocoa agroforests

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Appendix A. Bird species.

Table A1. Bird species recorded on 10 cocoa agroforests located in Bahia state, Brazil.

Family/Species	Number of records	Habitat specialization
Tinamidae		
<i>Crypturellus soui</i>	24	Forest species
Columbidae		
<i>Patagioenas speciosa</i>	14	Forest species
<i>Patagioenas picazuro</i>	4	Non-forest species
<i>Patagioenas cayennensis</i>	11	Non-forest species
<i>Leptotila verreauxi</i>	8	Forest species
<i>Leptotila rufaxilla</i>	12	Forest species
<i>Columbina talpacoti</i>	9	Non-forest species
<i>Columbina squammata</i>	15	Non-forest species
Cuculidae		
<i>Crotophaga ani</i>	23	Non-forest species
<i>Piaya cayana</i>	45	Forest species
Caprimulgidae		
<i>Nyctidromus albicollis</i>	1	Non-forest species
Trochilidae		
<i>Florisuga fusca</i>	4	Non-forest species
<i>Glaucis dornii</i>	10	Forest species
<i>Glaucis hirsutus</i>	116	Forest species
<i>Phaethornis ruber</i>	36	Forest species
<i>Eupetomena macroura</i>	39	Non-forest species
<i>Aphantochroa cirrochloris</i>	35	Non-forest species
<i>Chrysurnia leucogaster</i>	10	Non-forest species
<i>Chionomesa fimbriata</i>	8	Non-forest species
<i>Hylocharis sapphirina</i>	17	Non-forest species
<i>Chlorestes notata</i>	27	Non-forest species
Rallidae		
<i>Pardirallus nigricans</i>	3	Non-forest species
Chatartidae		
<i>Cathartes burrovianus</i>	3	Non-forest species
<i>Cathartes aura</i>	3	Non-forest species
Accipitridae		
<i>Leptodon cayanensis</i>	1	Forest species
<i>Geranospiza caerulescens</i>	1	Non-forest species
<i>Rupornis magnirostris</i>	14	Non-forest species
<i>Pseudastur polionotus</i>	2	Forest species
<i>Buteo nitidus</i>	4	Forest species
Strigidae		
<i>Glaucidium brasilianum</i>	3	Non-forest species
<i>Glaucidium minutissimum</i>	23	Forest species
Trogonidae		
<i>Trogon viridis</i>	55	Forest species
Alcedinidae		
<i>Megaceryle torquata</i>	2	Non-forest species
<i>Chloroceryle inda</i>	8	Forest species
Galbulidae		

<i>Galbula ruficauda</i>	50	Forest species
Bucconidae		
<i>Chelidoptera tenebrosa</i>	15	Non-forest species
<i>Monasa morphoeus</i>	9	Forest species
Ramphastidae		
<i>Ramphastos vitellinus</i>	14	Forest species
<i>Pteroglossus aracari</i>	66	Forest species
Picidae		
<i>Picumnus pygmaeus</i>	20	Non-forest species
<i>Melanerpes flavifrons</i>	75	Forest species
<i>Veniliornis affinis</i>	17	Forest species
<i>Dryocopus lineatus</i>	21	Non-forest species
<i>Celeus flavescens</i>	6	Forest species
<i>Celeus torquatus</i>	2	Forest species
<i>Piculus flavigula</i>	25	Forest species
<i>Colaptes melanochloros</i>	1	Non-forest species
Falconidae		
<i>Herpetotheres cachinnans</i>	7	Non-forest species
<i>Caracara plancus</i>	3	Non-forest species
Psittacidae		
<i>Brotogeris tirica</i>	72	Non-forest species
<i>Pyrrhura leucotis</i>	15	Forest species
<i>Amazona rhodocorytha</i>	2	Forest species
<i>Forpus xanthopterygius</i>	22	Non-forest species
<i>Touit surdus</i>	78	Forest species
<i>Pionus reichenowi</i>	22	Forest species
Thamnophilidae		
<i>Thamnophilus palliatus</i>	108	Non-forest species
<i>Thamnophilus ambiguus</i>	4	Forest species
<i>Taraba major</i>	4	Non-forest species
<i>Myrmotherula axillaris</i>	14	Forest species
Dendrocolaptidae		
<i>Sittasomus griseicapillus</i>	39	Forest species
<i>Dendrocincla turdina</i>	34	Forest species
<i>Glyphorhynchus spirurus</i>	7	Forest species
<i>Dendrocolaptes platyrostris</i>	8	Forest species
<i>Xiphorhynchus fuscus</i>	60	Forest species
<i>Xiphorhynchus guttatus</i>	16	Forest species
<i>Dendroplex picus</i>	74	Forest species
Xenopidae		
<i>Xenops rutilans</i>	14	Forest species
Furnaridae		
<i>Furnarius figulus</i>	10	Non-forest species
<i>Pseudoseisura cristata</i>	3	Non-forest species
<i>Acrobatornis fonsecai</i>	13	Non-forest species
<i>Certhiaxis cinnamomeus</i>	8	Non-forest species
<i>Furnarius leucopus</i>	4	Non-forest species
Pipridae		
<i>Manacus manacus</i>	51	Forest species
<i>Machaeropterus regulus</i>	17	Forest species

<i>Pseudopipra pipra</i>	8	Forest species
<i>Ceratopipra rubrocapilla</i>	98	Forest species
Tityridae		
<i>Tityra cayana</i>	28	Non-forest species
<i>Pachyramphus marginatus</i>	155	Forest species
<i>Pachyramphus viridis</i>	16	Forest species
<i>Pachyramphus polychopterus</i>	6	Forest species
<i>Pachyramphus validus</i>	4	Forest species
Onychorhynchidae		
<i>Myiobius barbatus</i>	29	Forest species
Rhynchocyclidae		
<i>Leptopogon amaurocephalus</i>	28	Forest species
<i>Myiornis auricularis</i>	82	Forest species
<i>Tolmomyias flaviventris</i>	331	Forest species
<i>Tolmomyias poliocephalus</i>	76	Forest species
<i>Tolmomyias sulphureus</i>	5	Forest species
<i>Todirostrum cinereum</i>	192	Non-forest species
<i>Todirostrum poliocephalum</i>	61	Forest species
Tyrannidae		
<i>Camptostoma obsoletum</i>	21	Non-forest species
<i>Elaenia flavogaster</i>	76	Non-forest species
<i>Megarynchus pitangua</i>	191	Non-forest species
<i>Myiozetetes similis</i>	235	Non-forest species
<i>Tyrannus melancholicus</i>	82	Non-forest species
<i>Attila rufus</i>	42	Forest species
<i>Attila spadiceus</i>	2	Forest species
<i>Capsiempis flaveola</i>	8	Forest species
<i>Lathrotriccus euleri</i>	121	Forest species
<i>Myiarchus ferox</i>	100	Non-forest species
<i>Myiarchus tuberculifer</i>	38	Forest species
<i>Rhytipterna simplex</i>	51	Forest species
<i>Pitangus sulphuratus</i>	424	Non-forest species
<i>Fluvicola nengeta</i>	18	Non-forest species
<i>Empidonomus varius</i>	21	Non-forest species
Vireonidae		
<i>Cyclarhis gujanensis</i>	23	Non-forest species
<i>Vireo chivi</i>	115	Forest species
Troglodytidae		
<i>Troglodytes musculus</i>	116	Non-forest species
<i>Campylorhynchus turdinus</i>	151	Forest species
<i>Pheugopedius genibarbis</i>	8	Forest species
Donacobiidae		
<i>Donacobius atricapilla</i>	17	Non-forest species
Turdidae		
<i>Turdus leucomelas</i>	496	Non-forest species
<i>Turdus rufiventris</i>	421	Non-forest species
<i>Turdus amaurochalinus</i>	11	Forest species
Fringillidae		
<i>Euphonia chlorotica</i>	183	Non-forest species
<i>Euphonia violacea</i>	290	Non-forest species

<i>Euphonia xanthogaster</i>	7	Forest species
<i>Euphonia pectoralis</i>	5	Forest species
Passerellidae		
<i>Arremon taciturnus</i>	14	Forest species
Icteridae		
<i>Psarocolius decumanus</i>	5	Forest species
<i>Cacicus cela</i>	827	Non-forest species
<i>Cacicus haemorrhous</i>	11	Forest species
<i>Icterus jamaicae</i>	27	Non-forest species
<i>Gnorimopsar chopi</i>	6	Non-forest species
Parulidae		
<i>Setophaga pitiauyumi</i>	76	Forest species
<i>Myiothlypis rivularis</i>	2	Forest species
Thraupidae		
<i>Thraupis palmarum</i>	360	Non-forest species
<i>Thraupis sayaca</i>	161	Non-forest species
<i>Tangara cyanomelas</i>	197	Forest species
<i>Tangara seledon</i>	228	Forest species
<i>Saltator maximus</i>	222	Non-forest species
<i>Dacnis cayana</i>	122	Non-forest species
<i>Nemosia pileata</i>	63	Non-forest species
<i>Stelpnia cayana</i>	57	Non-forest species
<i>Sicalis flaveola</i>	12	Non-forest species
<i>Cyanerpes cyaneus</i>	15	Forest species
<i>Chlorophanes spiza</i>	7	Forest species
<i>Tachyphonus rufus</i>	8	Non-forest species
<i>Ramphocelus bresilia</i>	116	Non-forest species
<i>Coereba flaveola</i>	397	Non-forest species

Appendix B. Overdispersion test.

We evaluated overdispersion in the models using the `check_overdispersion` function from the `performance` package (Lüdecke et al., 2021) in R (R Development Core Team, 2023). This procedure relies on the dispersion ratio and a chi-squared distribution to determine whether overdispersion is present (Da Silva et al. 2022). According to Da Silva et al. (2022), a $p\text{-value} \leq 0.05$ indicates significant overdispersion.

Table B1. Overdispersion test on the residuals of significant models ($P \leq 0.05$) used to explain the effect of management intensity on forest bird richness and the abundance of forest and non-forest birds.

Models	dispersion ratio	P-value
Model = Forest Bird Richness ~ Management Intensity	0.485	0.224
Model = Forest Bird Abundance ~ Management Intensity	1.172	0.576
Model = Non-Forest Bird Abundance ~ Management Intensity	1.116	0.672

References

Da Silva FR, Gonçalves-Souza T, Paterno GB, Provete DB, Vancine MH (2022) Análises ecológicas no R. Nupeea: Recife, PE 978-85-7917-564-0.

Lüdecke D, Ben-Shachar MS, Patil I, Waggoner P, Makowski D (2021) performance: An R package for assessment, comparison and testing of statistical models. Journal of Open Source Software: 6(60).

R Core Team (2023) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Appendix C. Spatial autocorrelation test.

To assess spatial autocorrelation in the residuals of significant models ($P \leq 0.05$), we applied Moran's I test (Legendre 1993) using the geographic coordinates (latitude and longitude) of the sampling sites. For this analysis, we generated an inverse distance matrix with zero values on the diagonal to represent spatial relationships and then tested the residuals of the GLM accordingly, following the procedure described by Guisan et al. (2017). In this method, p-values ≤ 0.05 are considered evidence of spatial autocorrelation (Gittleman and Kot 1990).

Table C1. Spatial autocorrelation test on residues of significant models ($P \leq 0.05$) used to explain the effect of management intensity on forest bird richness and the abundance of forest and non-forest birds.

Models	P-value	Moran's I
Model = Forest Bird Richness ~ Management Intensity	0.765	-0.162
Model = Forest Bird Abundance ~ Management Intensity	0.741	-0.167
Model = Non-Forest Bird Abundance ~ Management Intensity	0.873	-0.139

References

- Gittleman JL, Kot M (1990) Adaptation: statistics and a null model for estimating phylogenetic effects. *Syst. Zool* 39: 227–241.
- Guisan A, Thuiller W, Zimmermann NE (2017) *Habitat suitability and distribution models: with applications in R*. Cambridge University Press.
- Legendre P (1993) Spatial autocorrelation: trouble or new paradigm? *Ecology* 74: 1659–1673.

Appendix D. Relationship between management intensity and forest cover for some parameters of the bird community.

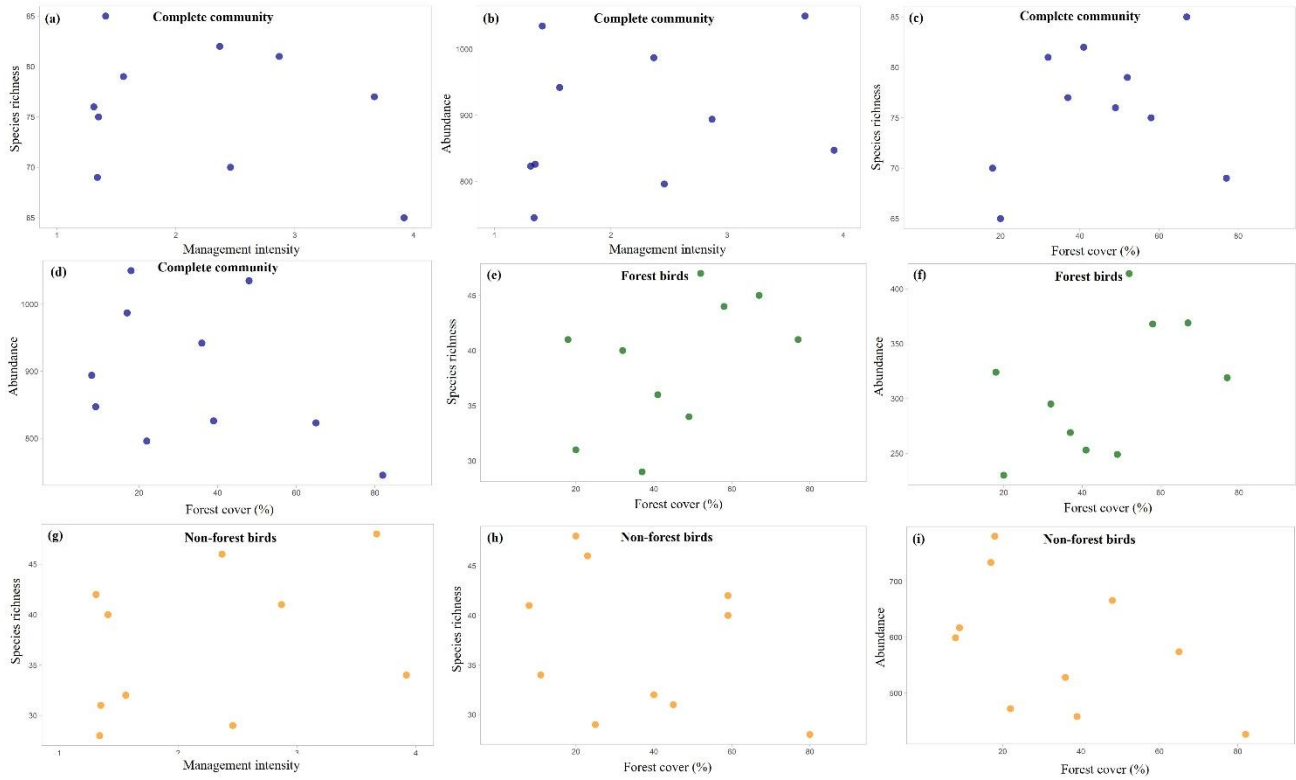


Fig. D1. Non-significant relationships between the management intensity and forest cover on bird species richness and abundance of the complete community (a–d), forest birds (e, f), and non-forest birds (g–i).

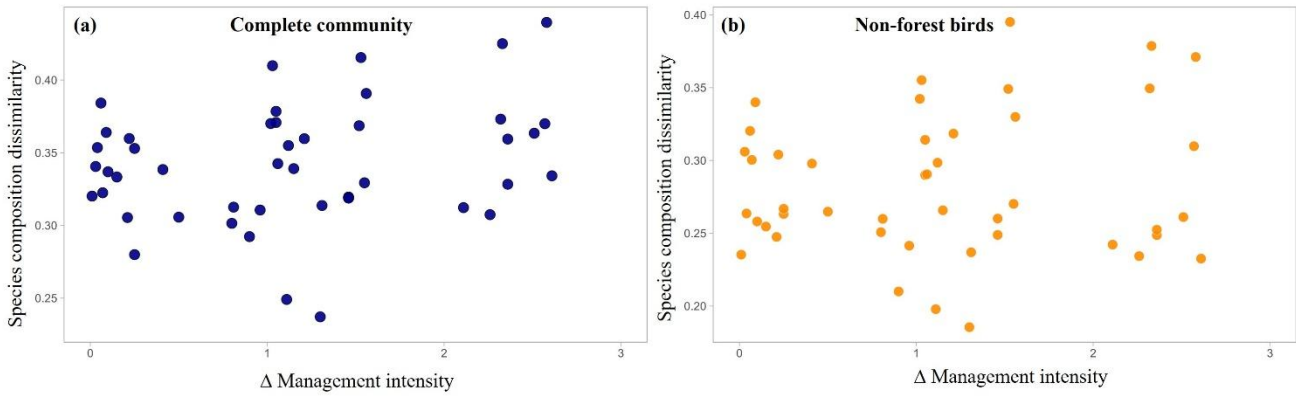


Fig. D2. Non-significant relationships of differences (Δ) in management intensity between pairs of agroforest sites on the dissimilarity of composition of the complete bird community (a, $r = 0.23$; $p = 0.07$) and non-forest birds (b, $r = 0.09$; $p = 0.27$).

Appendix E. Statistical parameters of the GLM models.

Table E1. Parameters of statistical models assessing the effects of the management intensity and landscape forest cover on bird richness and abundance (complete community, forest birds and non-forest birds). We highlight, in bold, the models with a significant effect of the predictor variable.

Predictor Variable	Response Variable	Estimate	Std. Error	Z-Value	P-Value
Management Intensity	Complete Community Richness	-0.024	0.038	-0.644	0.52
	Forest Bird Richness	-0.116	0.055	-2.096	0.037
	Non-Forest Bird Richness	0.066	0.053	1.225	0.22
	Complete Community Abundance	0.03	0.035	0.86	0.39
	Forest Bird Abundance	-0.125	0.048	-2.583	0.009
	Non-Forest Bird Abundance	0.107	0.054	1.994	0.046
Forest Cover	Complete Community Richness	0.0002	0.0016	0.169	0.866
	Forest Bird Richness	0.003	0.0023	1.407	0.16
	Non-Forest Bird Richness	-0.0029	0.0024	-1.197	0.231
	Complete Community Abundance	-0.0011	0.0015	-0.74	0.459
	Forest Bird Abundance	0.0041	0.0023	1.748	0.08
	Non-Forest Bird Abundance	-0.004	0.0025	-1.599	0.11