

Appendix to Birds and beans: Comparing avian richness and endemism in *arabica* and *robusta* agroforests in India's Western Ghats

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Running headline: *Avian endemism and richness in arabica and robusta agroforests*

Table A1: The five most common species of each category observed in arabica and robusta plantations.

Crop	Forest-dependent	Endemic	Frugivore	Insectivore	Omnivore
<i>Arabica</i>	Cinnyris lotenius (100)	Ocyeros griseus (77.2)	Cinnyris lotenius (100)	Vanellus indicus (99.4)	Amaurornis phoenicurus (100)
	Cuculus micropterus (85.6)	Psilopogon malabaricus (41.1)	Ocyeros griseus (77.2)	Copsychus saularis (86.1)	Parus major (67.8)
	Ocyeros griseus (77.2)	Turdoides subrufa (27.2)	Dicaeum agile (59.4)	Cuculus micropterus (85.6)	Acridotheres tristis (60)
	Sitta frontalis (75.6)	Pycnonotus gularis (20)	Dicaeum erythrorhynchos (56.1)	Sitta frontalis (75.6)	Coracias benghalensis (53.3)
	Hemicircus canente (68.9)	Galloperdix spadicea (10.6)	Columba elphinstonii (46.7)	Hemicircus canente (68.9)	Centropus sinensis (37.8)
<i>Robusta</i>	Cinnyris lotenius (96.7)	Ocyeros griseus (72.8)	Cinnyris lotenius (96.7)	Vanellus indicus (101.7)	Amaurornis phoenicurus (103.3)
	Cuculus micropterus (78.9)	Psilopogon malabaricus (40.6)	Ocyeros griseus (72.8)	Cuculus micropterus (78.9)	Parus major (77.8)
	Sitta frontalis (78.3)	Pycnonotus gularis (22.2)	Dicaeum erythrorhynchos (69.4)	Sitta frontalis (78.3)	Acridotheres tristis (51.1)
	Hemicircus canente (77.8)	Turdoides subrufa (19.4)	Psittacula cyanocephala (43.9)	Hemicircus canente (77.8)	Coracias benghalensis (50)
	Chrysocolaptes guttacristatus (73.3)	Galloperdix spadicea (7.2)	Columba elphinstonii (41.1)	Chrysocolaptes guttacristatus (73.3)	Centropus sinensis (34.4)

*: User% refers to the percentage of surveyed growers for each coffee strain that use this particular input; pay % is the proportion of respondents who paid for these inputs. Mean (standard error) refers to the average amount of money (2013 \$USD) per hectare paid per input, and range shows the minimum and maximum per hectare costs associated with each input.

Table A2: Forest-dependent richness model comparison

Variables (β (SE))	Models							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop: Robusta	0.33 (2.77)	-0.58 (2.58)				0.76 (2.28)	0.27 (2.24)	0.35 (2.26)
Tree richness	0.53 (1.10)	0.40 (1.08)						0.55 (1.00)
Tree density	-0.03 (1.22)	-0.36 (1.15)	-0.49 (1.05)	-0.39 (1.08)				
Canopy density	-1.67 (1.37)	-1.22 (1.27)	-1.03 (1.14)	-1.06 (1.15)				
Canopy structure	1.10 (1.21)							
Tree cover	1.43 (1.08)	1.33 (1.04)	1.37 (1.02)	1.30 (1.04)	1.02 (1.00)	1.09 (1.02)		
Distance to PA	-0.51 (1.11)			-0.44 (1.09)	-0.57 (1.05)	-0.58 (1.06)	-0.77 (1.05)	-0.73 (1.06)
Pesticide use	0.68 (1.25)	0.38 (1.17)	0.55 (1.05)	0.69 (1.11)	0.30 (1.04)	0.50 (1.20)	0.32 (1.19)	0.23 (1.21)
Constant	30.10*** (1.72)	30.56*** (1.64)	30.27*** (0.96)	30.27*** (0.97)	30.27*** (0.96)	29.88*** (1.51)	30.13*** (1.50)	30.09*** (1.51)
N	61	61	61	61	61	61	61	61
Log Likelihood	-207.29	-207.86	-207.97	-207.88	-208.64	-208.58	-209.19	-209.03
AIC	432.57	429.72	425.95	427.77	425.28	427.16	426.38	428.05

* p < .1; ** p < .05; *** p < .01

Table A3: Endemic richness model comparison

Variables (β (SE))	Model							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop: Robusta	0.8 (0.8)	1.0 (0.8)				1.0 (0.8)	0.9 (0.8)	0.7 (0.7)
Tree richness	-1.5*** (0.3)	-1.5*** (0.3)						-1.5*** (0.3)
Tree density	-0.03 (0.4)	0.1 (0.4)	0.6 (0.4)	0.6 (0.4)				
Canopy density	0.3 (0.4)	0.2 (0.4)	-0.3 (0.4)	-0.3 (0.4)				
Canopy structure	-0.3 (0.4)							
Tree cover	0.1 (0.3)	0.1 (0.3)	-0.01 (0.4)	0.01 (0.4)	-0.05 (0.4)	0.04 (0.4)		
Distance to PA	0.2 (0.3)			0.2 (0.4)	0.3 (0.4)	0.3 (0.4)	0.3 (0.4)	0.2 (0.3)
Pesticide use	-0.2 (0.4)	-0.1 (0.4)	-0.5 (0.4)	-0.5 (0.4)	-0.6 (0.4)	-0.4 (0.4)	-0.4 (0.4)	-0.2 (0.4)
Constant	-0.2 (0.5)	-0.4 (0.5)	0.2 (0.3)	0.2 (0.4)	0.2 (0.4)	-0.3 (0.5)	-0.3 (0.5)	-0.2 (0.5)
N	61	61	61	61	61	61	61	61
Log Likelihood	-135.2	-135.7	-146.1	-146.0	-147.1	-146.4	-146.4	-135.8
AIC	288.4	285.5	302.2	304.0	302.3	302.8	300.8	281.6

* $p < .1$; ** $p < .05$; *** $p < .01$

Table A4: Frugivore density model comparison

Variables (β (SE))	Model							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop: Robusta	1.1 (0.9)	1.1 (0.9)				0.7 (0.8)	0.6 (0.7)	0.7 (0.7)
Tree richness	0.3 (0.4)	0.3 (0.4)						0.4 (0.3)
Tree density	-0.2 (0.4)	-0.1 (0.4)	-0.3 (0.4)	-0.5 (0.4)				
Canopy density	0.3 (0.5)	0.3 (0.4)	0.2 (0.4)	0.2 (0.4)				
Canopy structure	0.3 (0.4)							
Tree cover	0.2 (0.4)	0.1 (0.4)	0.04 (0.4)	0.2 (0.3)	0.2 (0.3)	0.3 (0.3)		
Distance to PA	0.7* (0.4)			0.8** (0.4)	0.7* (0.3)	0.6* (0.3)	0.6* (0.3)	0.6* (0.3)
Pesticide use	-0.1 (1.6)	0.7 (1.6)	0.1 (1.4)	-0.8 (1.5)	-0.6 (1.4)	0.2 (1.6)	-0.005 (1.6)	-0.3 (1.6)
Constant	4.0*** (0.7)	3.9*** (0.7)	4.6*** (0.4)	4.7*** (0.4)	4.7*** (0.4)	4.2*** (0.6)	4.3*** (0.6)	4.3*** (0.6)
N	61	61	61	61	61	61	61	61
Log Likelihood	-139.3	-141.7	-142.9	-140.5	-141.4	-140.9	-141.3	-140.4
AIC	296.6	297.5	295.8	293.0	290.8	291.8	290.5	290.8

* $p < .1$; ** $p < .05$; *** $p < .01$

Table A5: Insectivore density model comparison

Variables (β (SE))	Model							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop: Robusta	-0.1 (0.5)	0.1 (0.5)				0.4 (0.4)	0.3 (0.4)	0.3 (0.4)
Tree richness	-0.1 (0.2)	-0.03 (0.2)						0.04 (0.2)
Tree density	-0.3 (0.2)	-0.2 (0.2)	-0.2 (0.2)	-0.2 (0.2)				
Canopy density	-0.2 (0.2)	-0.2 (0.2)	-0.3 (0.2)	-0.2 (0.2)				
Canopy structure	-0.2 (0.2)							
Tree cover	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.2 (0.2)	0.1 (0.2)	0.1 (0.2)		
Distance to PA	0.2 (0.2)			0.2 (0.2)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)
Pesticide use	-0.4 (0.9)	-0.1 (0.8)	-0.2 (0.8)	-0.4 (0.8)	-0.8 (0.8)	-0.4 (0.9)	-0.5 (0.9)	-0.5 (0.9)
Constant	2.9*** (0.4)	2.8*** (0.4)	2.8*** (0.2)	2.9*** (0.2)	2.9*** (0.2)	2.7*** (0.4)	2.7*** (0.3)	2.7*** (0.3)
N	61	61	61	61	61	61	61	61
Log Likelihood	-102.1	-102.9	-103.0	-102.5	-104.6	-104.2	-104.5	-104.4
AIC	222.2	219.9	216.0	217.0	217.2	218.3	216.9	218.9

* p < .1; ** p < .05; *** p < .01

Table A6: Omnivore density model comparison

Variables (β (SE))	Model							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop: Robusta	0.2 (0.7)	0.5 (0.7)				0.8 (0.6)	0.9 (0.6)	0.8 (0.6)
Tree richness	-0.3 (0.3)	-0.3 (0.3)						-0.1 (0.3)
Tree density	-0.6* (0.3)	-0.4 (0.3)	-0.3 (0.3)	-0.5 (0.3)				
Canopy density	0.02 (0.4)	-0.1 (0.4)	-0.2 (0.3)	-0.2 (0.3)				
Canopy structure	-0.2 (0.3)							
Tree cover	-0.2 (0.3)	-0.3 (0.3)	-0.3 (0.3)	-0.2 (0.3)	-0.3 (0.3)	-0.2 (0.3)		
Distance to PA	0.7** (0.3)			0.7** (0.3)	0.6** (0.3)	0.6** (0.3)	0.6** (0.3)	0.6** (0.3)
Pesticide use	0.9 (1.3)	2.0 (1.3)	1.5 (1.2)	0.6 (1.2)	0.2 (1.1)	1.0 (1.3)	1.2 (1.3)	1.3 (1.3)
Constant	3.9*** (0.6)	3.6*** (0.6)	3.9*** (0.3)	4.0*** (0.3)	4.1*** (0.3)	3.6*** (0.5)	3.5*** (0.5)	3.5*** (0.5)
N	61	61	61	61	61	61	61	61
Log Likelihood	-126.4	-129.9	-130.7	-127.5	-129.8	-129.0	-129.3	-129.2
AIC	270.9	273.7	271.4	267.0	267.6	268.0	266.6	268.3

* $p < .1$; ** $p < .05$; *** $p < .01$

Appendix II: List of habitat specialization traits for all surveyed species

Table 1: Threat and endemism status for observed birds.

Original	Latin	Migratory	Threat	Endemism
Alexandrine Parakeet	<i>Psittacula eupatria</i>	0	NT	0
Grey-headed Bulbul	<i>Pycnonotus priocephalus</i>	0	NT	1
Flame-throated Bulbul	<i>Pycnonotus gularis</i>	0	LC	1
Malabar Woodshrike	<i>Tephrodornis sylvicola</i>	0	LC	1
Nilgiri Flowerpecker	<i>Dicaeum concolor</i>	0	LC	1
Red Spurfowl	<i>Galloperdix spadicea</i>	0	LC	1
Grey Junglefowl	<i>Gallus sonneratii</i>	0	LC	1
Malabar Barbet	<i>Psilopogon malabaricus</i>	0	LC	1
Malabar Grey Hornbill	<i>Ocyrceros griseus</i>	0	LC	1
Malabar Parakeet	<i>Psittacula columboides</i>	0	LC	1
Malabar Whistling Thrush	<i>Myophonus horsfieldii</i>	0	LC	1
Rufous Babbler	<i>Turdoides subrufa</i>	0	LC	1
Small Sunbird	<i>Leptocoma minima</i>	0	LC	1
White-bellied Blue-flycatcher	<i>Cyornis pallipes</i>	0	LC	1
White-cheeked Barbet	<i>Psilopogon viridis</i>	0	LC	1
Malabar Trogon	<i>Harpactes fasciatus</i>	0	LC	0
Nilgiri Wood-pigeon	<i>Columba elphinstonii</i>	0	VU	0
Collared Scops Owl	<i>Otus lettia</i>	0	LC	0
Common Flameback	<i>Dinopium javanense</i>	0	LC	0
Common Hawk Cuckoo	<i>Hierococcyx varius</i>	0	LC	0
Common Iora	<i>Aegithina tiphia</i>	0	LC	0
Common Myna	<i>Acridotheres tristis</i>	0	LC	0

Common Tailorbird	<i>Orthotomus sutorius</i>	0	LC	0
Common Woodshrike	<i>Tephrodornis pondicerianus</i>	0	LC	0
Coppersmith Barbet	<i>Psilopogon haemacephalus</i>	0	LC	0
Crested Goshawk	<i>Accipiter trivirgatus</i>	0	LC	0
Crested Serpent Eagle	<i>Spilornis cheela</i>	0	LC	0
Dark-fronted Babbler	<i>Rhopocichla atriceps</i>	0	LC	0
Drongo Cuckoo	<i>Surniculus dicruroides</i>	0	LC	0
Eastern Cattle Egret	<i>Bubulcus ibis</i>	0	LC	0
Emerald Dove	<i>Chalcophaps indica</i>	0	LC	0
Golden Oriole	<i>Oriolus kundoo</i>	0	LC	0
Ashy Wood Swallow	<i>Artamus fuscus</i>	0	LC	0
Asian Fairy Bluebird	<i>Irena puella</i>	0	LC	0
Asian Koel	<i>Eudynamys scolopaceus</i>	0	LC	0
Asian Paradise Flycatcher	<i>Terpsiphone paradisi</i>	0	LC	0
Banded Bay Cuckoo	<i>Cacomantis sonneratii</i>	0	LC	0
Bar-winged Flycatchershrike	<i>Hemipus picatus</i>	0	LC	0
Black Drongo	<i>Dicrurus macrocercus</i>	0	LC	0
Black-headed Cuckooshrike	<i>Coracina melanoptera</i>	0	LC	0
Black-hooded Oriole	<i>Oriolus xanthornus</i>	0	LC	0
Black-lored Tit	<i>Parus xanthogenys</i>	0	LC	0
Black-naped Monarch	<i>Hypothymis azurea</i>	0	LC	0
Black-rumped Flameback	<i>Dinopium benghalense</i>	0	LC	0
Black-shouldered Kite	<i>Elanus caeruleus</i>	0	LC	0
Black-throated Munia	<i>Lonchura kelaarti</i>	0	LC	0

Blue-bearded Bee-eater	Nyctyornis athertoni	0	LC	0
Brahminy Myna	Sturnia pagodarum	0	LC	0
Bronzed Drongo	Dicrurus aeneus	0	LC	0
Brown Fish Owl	Ketupa zeylonensis	0	LC	0
Brown Hawk Owl	Ninox scutulata	0	LC	0
Brown-capped Pygmy Woodpecker	Yungipicus nanus	0	LC	0
Brown-cheeked Fulvetta	Alcippe poioicephala	0	LC	0
Chestnut-headed Bee-eater	Merops leschenaulti	0	LC	0
Chestnut-shouldered Petronia	Gymnoris xanthocollis	0	LC	0
Golden-fronted Leafbird	Chloropsis aurifrons	0	LC	0
Great Tit	Parus major	0	LC	0
Greater Coucal	Centropus sinensis	0	LC	0
Greater Flameback	Chrysocolaptes guttacristatus	0	LC	0
Greater Racket-tailed Drongo	Dicrurus paradiseus	0	LC	0
Grey-bellied Cuckoo	Cacomantis passerinus	0	LC	0
Grey-fronted Green Pigeon	Treron affinis	0	LC	0
Heart-spotted Woodpecker	Hemicircus canente	0	LC	0
Hill Myna	Gracula indica	0	LC	0
Indian Cormorant	Phalacrocorax fuscicollis	0	LC	0
Indian Cuckoo	Cuculus micropterus	0	LC	0
Indian Jungle Crow	Corvus macrorhynchos	0	LC	0
Indian Nuthatch	Sitta castanea	0	LC	0
Indian Peafowl	Pavo cristatus	0	LC	0
Indian Pond Heron	Ardeola grayii	0	LC	0

Indian Roller	<i>Coracias benghalensis</i>	0	LC	0
Indian Scimitar Babbler	<i>Pomatorhinus horsfieldii</i>	0	LC	0
Jerdons Leafbird	<i>Chloropsis jerdoni</i>	0	LC	0
Jungle Babbler	<i>Turdoides striata</i>	0	LC	0
Jungle Myna	<i>Acridotheres fuscus</i>	0	LC	0
Jungle Owlet	<i>Glaucidium radiatum</i>	0	LC	0
Large Cuckooshrike	<i>Coracina macei</i>	0	LC	0
Lesser Yellownape	<i>Picus chlorolophus</i>	0	LC	0
Little Egret	<i>Egretta garzetta</i>	0	LC	0
Little Spiderhunter	<i>Arachnothera longirostra</i>	0	LC	0
Long-tailed Shrike	<i>Lanius schach</i>	0	LC	0
Lotens Sunbird	<i>Cinnyris lotenius</i>	0	LC	0
Mottled Wood Owl	<i>Strix ocellata</i>	0	LC	0
Orange minivet	<i>Pericrocotus flammeus</i>	0	LC	0
Orange-headed Thrush	<i>Zoothera citrina</i>	0	LC	0
Oriental Honey Buzzard	<i>Pernis ptilorhynchus</i>	0	LC	0
Oriental Magpie Robin	<i>Copsychus saularis</i>	0	LC	0
Oriental White Eye	<i>Zosterops palpebrosus</i>	0	LC	0
Pale-billed Flowerpecker	<i>Dicaeum erythrorhynchos</i>	0	LC	0
Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	0	LC	0
Puff-throated Babbler	<i>Pellorneum ruficeps</i>	0	LC	0
Purple Sunbird	<i>Cinnyris asiaticus</i>	0	LC	0
Purple-rumped Sunbird	<i>Leptocoma zeylonica</i>	0	LC	0
Red-vented Bulbul	<i>Pycnonotus cafer</i>	0	LC	0
Red-wattled Lapwing	<i>Vanellus indicus</i>	0	LC	0

Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	0	LC	0
Rock Pigeon	<i>Columba livia</i>	0	LC	0
Rose-ringed Parakeet	<i>Psittacula krameri</i>	0	LC	0
Rufous Treepie	<i>Dendrocitta vagabunda</i>	0	LC	0
Rufous Woodpecker	<i>Micropternus brachyurus</i>	0	LC	0
Shikra	<i>Accipiter badius</i>	0	LC	0
Small Green Bee-eater	<i>Merops orientalis</i>	0	LC	0
Small Minivet	<i>Pericrocotus cinnameus</i>	0	LC	0
Spangled Drongo	<i>Dicrurus hottentottus</i>	0	LC	0
Speckled Piculet	<i>Picumnus innominatus</i>	0	LC	0
Spotted Dove	<i>Spilopelia suratensis</i>	0	LC	0
Square-tailed Black Bulbul	<i>Hypsipetes ganeesa</i>	0	LC	0
Thick-billed Flowerpecker	<i>Dicaeum agile</i>	0	LC	0
Tickells Blue Flycatcher	<i>Cyornis tickelliae</i>	0	LC	0
Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	0	LC	0
Vernal Hanging Parrot	<i>Loriculus vernalis</i>	0	LC	0
White-bellied Woodpecker	<i>Dryocopus javensis</i>	0	LC	0
White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	0	LC	0
White-rumped Munia	<i>Lonchura striata</i>	0	LC	0
White-rumped Shama	<i>Copsychus malabaricus</i>	0	LC	0
White-throated Kingfisher	<i>Halcyon smyrnensis</i>	0	LC	0
Yellow-browed Bulbul	<i>Acritillas indica</i>	0	LC	0
Yellow-crowned Woodpecker	<i>Leiopicus mahrattensis</i>	0	LC	0
Yellow-footed Green Pigeon	<i>Treron phoenicopterus</i>	0	LC	0

Table 2: Forest-dependency of the observed avifauna.

Scientific Name	Category	Source
Dicrurus leucophaeus	5	Anand
Monticola cinclorhynchus	5	Anand
Muscicapa dauurica	5	Anand
Eumyias thalassina	5	Anand
Luscinia brunnea	5	Anand
Acrocephalus dumetorum	5	Anand
Phylloscopus trochiloides	5	Anand
Phylloscopus magnirostris	5	Anand
Phylloscopus occipitalis	5	Anand
Dendronanthus indicus	5	Anand
Motacilla cinerea	5	Anand
Carpodacus erythrinus	5	Anand
Psilopogon viridis	1	Anand
Psilopogon rubricapilla	1	Anand
Ocyeros griseus	1	Anand
Harpactes fasciatus	1	Anand
Psittacula columboides	1	Anand
Dendrocitta leucogastra	1	Anand
Myophonus horsfieldii	1	Anand
Cyornis pallipes	1	Anand
Acritillas indica	1	Anand
Pomatorhinus horsfieldii	1	Anand
Rhopocichla atriceps	1	Anand

<i>Turdoides subrufa</i>	1	Anand
<i>Leptocoma minima</i>	1	Anand
<i>Cinnyris lotenius</i>	1	Anand
<i>Lonchura kelaarti</i>	1	Anand
<i>Picumnus innominatus</i>	2	Anand
<i>Hemicircus canente</i>	2	Anand
<i>Dinopium javanense</i>	2	Anand
<i>Ducula badia</i>	2	Anand
<i>Treron affinis</i>	2	Anand
<i>Accipiter trivirgatus</i>	2	Anand
<i>Accipiter virgatus</i>	2	Anand
<i>Irena puella</i>	2	Anand
<i>Tephrodornis gularis</i>	2	Anand
<i>Pycnonotus melanicterus</i>	2	Anand
<i>Hypsipetes ganeesa</i>	2	Anand
<i>Dicaeum concolor</i>	2	Anand
<i>Arachnothera longirostra</i>	2	Anand
<i>Galloperdix spadicea</i>	3	Anand
<i>Gallus sonneratii</i>	3	Anand
<i>Celeus brachyurus</i>	3	Anand
<i>Dryocopus javensis</i>	3	Anand
<i>Yungipicus nanus</i>	3	Anand
<i>Leiopicus mahrattensis</i>	3	Anand
<i>Picus chlorolophus</i>	3	Anand
<i>Chrysocolaptes guttacristatus</i>	3	Anand

Merops leschenaulti	3	Anand
Cacomantis sonneratii	3	Anand
Centropus sinensis	3	Anand
Loriculus vernalis	3	Anand
Psittacula cyanocephala	3	Anand
Bubo bubo	3	Anand
Chalcophaps indica	3	Anand
Spilornis cheela	3	Anand
Chloropsis jerdoni	3	Anand
Chloropsis aurifrons	3	Anand
Dendrocitta vagabunda	3	Anand
Oriolus kundoo	3	Anand
Pericrocotus cinnamomeus	3	Anand
Pericrocotus flammeus	3	Anand
Hemipus picatus	3	Anand
Dicrurus aeneus	3	Anand
Dicrurus hottentottus	3	Anand
Dicrurus paradiseus	3	Anand
Hypothymis azurea	3	Anand
Terpsiphone paradisi	3	Anand
Zoothera citrina	3	Anand
Turdus merula	3	Anand
Cyornis tickelliae	3	Anand
Culicicapa ceylonensis	3	Anand
Copsychus malabaricus	3	Anand

<i>Sturnus malabaricus</i>	3	Anand
<i>Gracula indica</i>	3	Anand
<i>Sitta frontalis</i>	3	Anand
<i>Sitta castanea</i>	3	Anand
<i>Parus xanthogenys</i>	3	Anand
<i>Pellorneum ruficeps</i>	3	Anand
<i>Alcippe poiocephala</i>	3	Anand
<i>Dicaeum agile</i>	3	Anand
<i>Gymnoris xanthocollis</i>	3	Anand
<i>Pavo cristatus</i>	4	Anand
<i>Dinopium benghalense</i>	4	Anand
<i>Upupa epops</i>	4	Anand
<i>Halcyon smyrnensis</i>	4	Anand
<i>Psittacula krameri</i>	4	Anand
<i>Streptopelia chinensis</i>	4	Anand
<i>Accipiter badius</i>	4	Anand
<i>Corvus macrorhynchos</i>	4	Anand
<i>Coracina macei</i>	4	Anand
<i>Aegithina tiphia</i>	4	Anand
<i>Copsychus saularis</i>	4	Anand
<i>Acridotheres fuscus</i>	4	Anand
<i>Pycnonotus jocosus</i>	4	Anand
<i>Pycnonotus cafer</i>	4	Anand
<i>Prinia socialis</i>	4	Anand
<i>Zosterops palpebrosus</i>	4	Anand

<i>Orthotomus sutorius</i>	4	Anand
<i>Turdoides striata</i>	4	Anand
<i>Dicaeum erythrorhynchos</i>	4	Anand
<i>Cinnyris asiaticus</i>	4	Anand
<i>Abroscopus superciliaris</i>	4	Beukema
<i>Accipiter gularis</i>	5	Beukema
<i>Accipiter trivirgatus</i>	3	Beukema
<i>Aegithina tiphia</i>	4	Beukema
<i>Aegithina viridissima</i>	3	Beukema
<i>Aethopyga siparaja</i>	4	Beukema
<i>Alcippe brunneicauda</i>	3	Beukema
<i>Amaurornis phoenicurus</i>	5	Beukema
<i>Anorrhinus galeritus</i>	3	Beukema
<i>Anthracoceros albirostris</i>	4	Beukema
<i>Anthracoceros malayanus</i>	4	Beukema
<i>Anthreptes malacensis</i>	5	Beukema
<i>Anthreptes rhodolaema</i>	4	Beukema
<i>Anthreptes simplex</i>	3	Beukema
<i>Anthreptes singalensis</i>	4	Beukema
<i>Aplonis panayensis</i>	5	Beukema
<i>Arachnothera affinis</i>	3	Beukema
<i>Arachnothera chrysogenys</i>	3	Beukema
<i>Arachnothera flavigaster</i>	3	Beukema
<i>Arachnothera longirostra</i>	3	Beukema
<i>Arachnothera robusta</i>	3	Beukema

<i>Argusianus argus</i>	3	Beukema
<i>Aviceda jerdoni</i>	3	Beukema
<i>Blythipicus rubiginosus</i>	3	Beukema
<i>Buceros rhinoceros</i>	3	Beukema
<i>Cacomantis merulinus</i>	5	Beukema
<i>Cacomantis sonneratii</i>	4	Beukema
<i>Calorhamphus fuliginosus</i>	4	Beukema
<i>Calyptomena viridis</i>	3	Beukema
<i>Micropternus brachyurus</i>	4	Beukema
<i>Centropus bengalensis</i>	5	Beukema
<i>Centropus sinensis</i>	5	Beukema
<i>Cettia vulcania</i>	3	Beukema
<i>Ceyx erithacus</i>	3	Beukema
<i>Chalcophaps indica</i>	3	Beukema
<i>Chloropsis cochinchinensis</i>	4	Beukema
<i>Chloropsis cyanopogon</i>	4	Beukema
<i>Chloropsis sonnerati</i>	3	Beukema
<i>Chrysococcyx xanthorhynchus</i>	4	Beukema
<i>Copsychus malabaricus</i>	3	Beukema
<i>Copsychus saularis</i>	5	Beukema
<i>Coracina striata</i>	3	Beukema
<i>Corvus enca</i>	4	Beukema
<i>Corvus macrorhynchos</i>	5	Beukema
<i>Criniger bres</i>	3	Beukema
<i>Criniger ochraceus</i>	3	Beukema

<i>Criniger phaeocephalus</i>	3	Beukema
<i>Culicicapa ceylonensis</i>	3	Beukema
<i>Cymbirhynchus macrorhynchos</i>	4	Beukema
<i>Cyornis tickelliae</i>	4	Beukema
<i>Cyornis turcosus</i>	3	Beukema
<i>Dicaeum cruentatum</i>	4	Beukema
<i>Dicaeum trigonostigma</i>	4	Beukema
<i>Dicrurus aeneus</i>	4	Beukema
<i>Dicrurus paradiseus</i>	4	Beukema
<i>Dinopium javanense</i>	4	Beukema
<i>Dinopium rafflesii</i>	3	Beukema
<i>Dryocopus javensis</i>	3	Beukema
<i>Ducula aenea</i>	3	Beukema
<i>Eupetes macrocerus</i>	3	Beukema
<i>Eurylaimus javanicus</i>	3	Beukema
<i>Eurylaimus ochromalus</i>	4	Beukema
<i>Eurystomus orientalis</i>	4	Beukema
<i>Gallus gallus</i>	4	Beukema
<i>Gracula religiosa</i>	4	Beukema
<i>Halcyon chloris</i>	5	Beukema
<i>Halcyon smyrnensis</i>	5	Beukema
<i>Harpactes diardii</i>	3	Beukema
<i>Harpactes duvaucelii</i>	3	Beukema
<i>Harpactes kasumba</i>	3	Beukema
<i>Harpactes orrhophaeus</i>	3	Beukema

<i>Hemicircus concretus</i>	4	Beukema
<i>Hemiprocne comata</i>	4	Beukema
<i>Hemipus hirundinaceus</i>	4	Beukema
<i>Hypogramma hypogrammicum</i>	3	Beukema
<i>Hypothymis azurea</i>	3	Beukema
<i>Hypsipetes charlottae</i>	3	Beukema
<i>Hypsipetes criniger</i>	3	Beukema
<i>Irena puella</i>	3	Beukema
<i>Kenopia striata</i>	3	Beukema
<i>Lalage nigra</i>	5	Beukema
<i>Lanius cristatus</i>	3	Beukema
<i>Lonchura leucogastra</i>	4	Beukema
<i>Lonchura striata</i>	5	Beukema
<i>Lophura erythrophthalma</i>	3	Beukema
<i>Loriculus galgulus</i>	4	Beukema
<i>Macronous gularis</i>	4	Beukema
<i>Macronous ptilosus</i>	3	Beukema
<i>Malacopteron affine</i>	3	Beukema
<i>Malacopteron cinereum</i>	3	Beukema
<i>Malacopteron magnirostre</i>	3	Beukema
<i>Malacopteron magnum</i>	3	Beukema
<i>Megalaima australis</i>	4	Beukema
<i>Megalaima chrysopogon</i>	3	Beukema
<i>Psilopogon haemacephalus</i>	5	Beukema
<i>Megalaima henricii</i>	3	Beukema

Megalaima mystacophanos	3	Beukema
Megalaima rafflesii	3	Beukema
Meiglyptes tristis	4	Beukema
Meiglyptes tukki	3	Beukema
Merops viridis	5	Beukema
Microhierax fringillarius	4	Beukema
Napothera macrodactyla	3	Beukema
Nectarinia jugularis	5	Beukema
Nectarinia sperata	4	Beukema
Nyctyornis amictus	3	Beukema
Oriolus chinensis	5	Beukema
Oriolus xanthonotus	3	Beukema
Orthotomus atrogularis	5	Beukema
Orthotomus ruficeps	5	Beukema
Orthotomus sericeus	4	Beukema
Pelargopsis capensis	5	Beukema
Pellorneum capistratum	3	Beukema
Pericrocotus cinnamomeus	4	Beukema
Pericrocotus flammeus	3	Beukema
Philentoma pyrhopterum	3	Beukema
Philentoma velatum	3	Beukema
Picus puniceus	3	Beukema
Platylophus galericulatus	3	Beukema
Platysmurus leucopterus	3	Beukema
Pomatorhinus montanus	3	Beukema

<i>Prinia atrogularis</i> *	4	Beukema
<i>Prinia familiaris</i>	5	Beukema
<i>Prinia flaviventris</i>	5	Beukema
<i>Prionochilus maculatus</i>	3	Beukema
<i>Prionochilus percussus</i>	3	Beukema
<i>Psittacula longicauda</i>	4	Beukema
<i>Psittinus cyanurus</i>	3	Beukema
<i>Ptilinopus jambu</i>	3	Beukema
<i>Pycnonotus atriceps</i>	4	Beukema
<i>Pycnonotus brunneus</i>	3	Beukema
<i>Pycnonotus cyaniventris</i>	3	Beukema
<i>Pycnonotus erythrophthalmos</i>	4	Beukema
<i>Pycnonotus eutilotus</i>	3	Beukema
<i>Pycnonotus goiavier</i>	5	Beukema
<i>Pycnonotus melanicterus</i>	4	Beukema
<i>Pycnonotus melanoleucos</i>	3	Beukema
<i>Pycnonotus plumosus</i>	5	Beukema
<i>Pycnonotus simplex</i>	3	Beukema
<i>Reinwardtipicus validus</i>	3	Beukema
<i>Rhamphococcyx curvirostris</i>	4	Beukema
<i>Rhinomyias olivacea</i>	3	Beukema
<i>Rhinomyias umbratilis</i>	3	Beukema
<i>Rhinoplax vigil</i>	3	Beukema
<i>Rhinortha chlorophaea</i>	4	Beukema
<i>Rhopodytes diardi</i>	4	Beukema

Rhopodytes sumatranus	3	Beukema
Rhyticeros corrugatus	3	Beukema
Rhyticeros undulatus	3	Beukema
Sasia abnormis	4	Beukema
Spilornis cheela	4	Beukema
Stachyris erythroptera	3	Beukema
Stachyris maculata	3	Beukema
Stachyris nigricollis	3	Beukema
Stachyris poliocephala	3	Beukema
Stachyris rufifrons	3	Beukema
Surniculus dicruroides	4	Beukema
Terpsiphone paradisi	3	Beukema
Treron olax	4	Beukema
Treron vernans	4	Beukema
Trichastoma abbotti	3	Beukema
Trichastoma bicolor	3	Beukema
Trichastoma malaccense	3	Beukema
Trichastoma pyrogenys	3	Beukema
Trichastoma sepiarium	3	Beukema
Zanclostomus javanicus	4	Beukema
Bubulcus ibis	4	Chang
Artamus fuscus	4	Chang
Dicrurus macrocercus	4	Chang
Parus major	4	Chang
Phalacrocorax fuscicollis	4	Chang

<i>Ardeola grayii</i>	4	Chang
<i>Coracias benghalensis</i>	4	Chang
<i>Egretta garzetta</i>	4	Chang
<i>Lanius schach</i>	4	Chang
<i>Leptocoma zeylonica</i>	4	Chang
<i>Vanellus indicus</i>	4	Chang
<i>Columba livia</i>	4	Chang
<i>Spilopelia suratensis</i>	4	Chang
<i>Eudynamys scolopaceus</i>	3	Chang
<i>Nyctornis athertoni</i>	3	Chang
<i>Cuculus micropterus</i>	3	Chang
<i>Pernis ptilorhynchus</i>	3	Chang
<i>Merops orientalis</i>	3	Chang
<i>Glaucidium radiatum</i>	2	Chang
<i>Psittacula eupatria</i>	3	Chang
<i>Pycnonotus priocephalus</i>	2	Chang
<i>Pycnonotus gularis</i>	3	Chang
<i>Tephrodornis sylvicola</i>	3	Chang
<i>Psilopogon malabaricus</i>	2	Chang
<i>Columba elphinstonii</i>	2	Chang
<i>Otus lettia</i>	4	Chang
<i>Hierococcyx varius</i>	3	Chang
<i>Acridotheres tristis</i>	4	Chang
<i>Tephrodornis pondicerianus</i>	3	Chang
<i>Coracina melanoptera</i>	3	Chang

Oriolus xanthornus	3	Chang
Elanus caeruleus	3	Chang
Sturnia pagodarum	3	Chang
Ketupa zeylonensis	2	Chang
Ninox scutulata	3	Chang
Cacomantis passerinus	4	Chang
Strix ocellata	4	Chang
Treron phoenicopterus	3	Chang

*Codes: 1-3 are habitat specialists (forest-dependent to woodland birds), 4 denotes plantation or open woodland species, 5 common or cosmopolitan species. Sources: Anand *et al.* 2008, Beukema *et al.* 2007, Chang *et al.* 2017 (compiled from del Hoyo *et al.* 2016, LePage 2016).

Birds and Beans: Replication Code

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Description

This document contains replication code and a dataset to accompany the manuscript “Birds and beans: Comparing avian richness and endemism in *arabica* and *robusta* plantations in India’s Western Ghats” by Charlotte H. Chang, Krithi K. Karanth, and Paul Robbins. An Rmarkdown HTML version of this code is posted at <http://rpubs.com/chwchang/WCS-India-Coffee> which may be more convenient for running analyses.

The central question addressed by this dataset is whether or not habitat specialist birds (forest-dependent, endemic, and IUCN Red-Listed species) exhibit different responses to *Coffea arabica* and *Coffea canephora* (*robusta* strain) plantations. Regional and global trends indicate that *robusta* production may be increasing at the cost of *arabica*, and this change may have biodiversity consequences as *robusta* is typically grown under full-sun, open habitat management, while *arabica* is more often shade-grown.

In this analysis, one can replicate habitat specialist individual-based rarefaction, asymptotic richness estimates, ordination, and distance-sampling abundance modeling.

Diversity analyses

Below, we load the Rdata containing the replication datasets. A description of each vector or dataframe is below:

- `FD.anon`: a vector of the column IDs for which species are forest-dependent
- `ED.anon`: a vector of column IDs for endemic species to India
- `IUCNbirds`: a vector of column IDs for IUCN Red-Listed species
- `coffee.SR.anon`: a data frame with counts for bird species across multiple estates with multiple replicates
- `FD.ds`: an R object from package `Distance` for forest-dependent bird abundance
- `End.ds`: Endemic abundance from package `Distance`
- `IUCN.ds`: IUCN Red-Listed species abundance from package `Distance`

```
###=====
### Load diversity data
###=====
## File download from GitHub repository - uncomment (remove leading hash) to run these two commands (wh
# githubURL <- "https://raw.githubusercontent.com/charlottehchang/WCS-India-Coffee/master/WCS_Archiving.Rdata"
# download.file(githubURL,"WCS_Archiving.Rdata")

load("WCS_Archiving.Rdata") # make sure the path to the downloaded Rdata archive is correct--currently
ls() # This shows you what is now contained in the workspace

## [1] "coffee.SR.anon" "ED.anon"          "End.ds"          "FD.anon"
## [5] "FD.ds"          "IUCN.anon"       "IUCN.ds"

###=====
### Estimate asymptotic richness
###=====
# If you do not have this package, please first use the command:
```

```

# install.packages(vegan) # Remove the leading hash to run this command
library('vegan') # load the vegan package and its functions

## Loading required package: permute
## Loading required package: lattice
## This is vegan 2.4-1

# Forest dependent analysis
print("Forest dependent species richness in arabica and robusta:")

## [1] "Forest dependent species richness in arabica and robusta:"
pool <- specpool(coffee.SR.anon[,FD.anon],coffee.SR.anon$Crop)
pool

##           Species      chao   chao.se    jack1 jack1.se    jack2    boot
## Arabica       74 88.00509 10.3463570 86.92778 3.852901 93.88315 79.74846
## Robusta       66 66.33154  0.7547849 67.98925 1.406610 64.06434 67.79705
##           boot.se    n
## Arabica 2.132692 180
## Robusta 1.173085 186

## IUCN Red-listed species richness
print("IUCN Red Listed richness in arabica and robusta:")

## [1] "IUCN Red Listed richness in arabica and robusta:"
pool2 <- specpool(coffee.SR.anon[,IUCN.anon],coffee.SR.anon$Crop)
pool2

##           Species chao chao.se jack1 jack1.se jack2 boot      boot.se    n
## Arabica         3   3      0    3      0    3   3 1.311930e-57 180
## Robusta         3   3      0    3      0    3   3 1.991371e-111 186

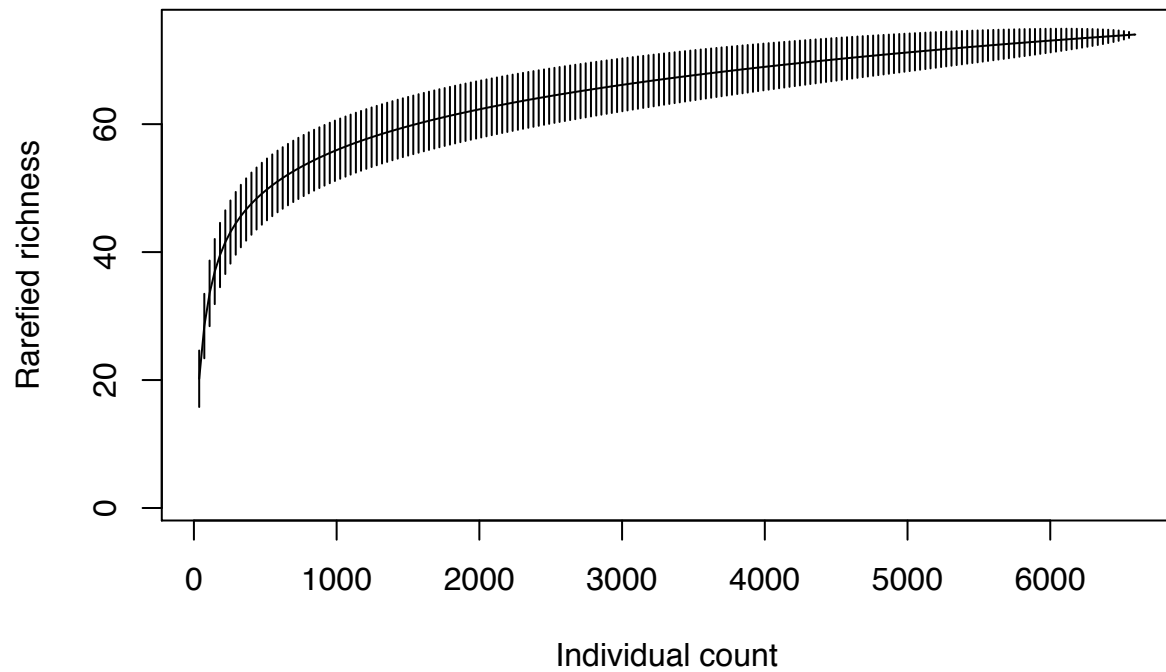
## Endemics
print("Endemic richness in arabica and robusta:")

## [1] "Endemic richness in arabica and robusta:"
pool3 <- specpool(coffee.SR.anon[,ED.anon],coffee.SR.anon$Crop)
pool3

##           Species      chao   chao.se    jack1 jack1.se    jack2    boot
## Arabica       14 20.21528 7.512247 18.97222 2.223645 21.94994 16.10231
## Robusta       11 11.00000 0.000000 11.00000 0.000000  9.03220 11.30508
##           boot.se    n
## Arabica 1.1690611 180
## Robusta 0.5243744 186

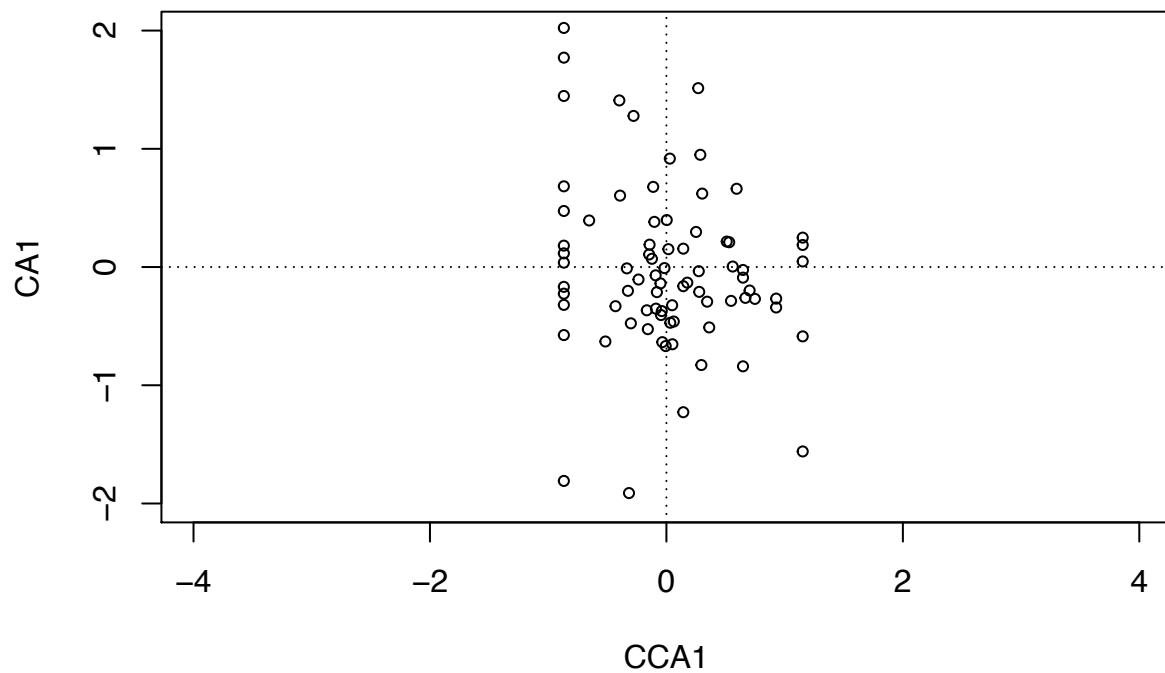
####=====
# ECOLOGICAL ANALYSES: INDIVIDUAL BASED RAREFACTION
####=====
# Run commands of the following variety below:
Rare.FD <- specaccum(coffee.SR.anon[coffee.SR.anon$Crop=="Arabica",FD.anon],method="rarefaction")
plot(Rare.FD, xlab="Individual count",xvar="individuals",ylab="Rarefied richness")

```



```
###=====
# ECOLOGICAL ANALYSES: ORDINATION
###=====

### Performing ordination
# Repeat for ED.anon for endemics if so desired.
# Calculate CCA
FD.CCA <- cca(coffee.SR.anon[,c(FD.anon)]~Crop, coffee.SR.anon)
# Plotting example
plot(FD.CCA, type="points", xlim=c(-2,2), ylim=c(-2,2), display="species", scaling="species")
```



```

###=====
# ECOLOGICAL ANALYSES: ABUNDANCE VIA DISTANCE
###=====
ha.m2 <- 10000 # converting hectares to meters-square
  ## Obtaining statistics from Distance analysis (package 'Distance' in R)
print("Forest dependent individual average detection:")

## [1] "Forest dependent individual average detection:"
FD.ds$dht$individuals$average.p

## [1] 0.0933786
print("Forest dependent cluster average detection:")

## [1] "Forest dependent cluster average detection:"
FD.ds$dht$clusters$average.p

## [1] 0.1399554
  ## Obtaining individual bird densities
print("Range of FD individual densities across arabica versus robusta estates:")

## [1] "Range of FD individual densities across arabica versus robusta estates:"
print("Arabica range:")

## [1] "Arabica range:"
round(range(FD.ds$dht$individuals$bySample$Dhat[FD.ds$dht$individuals$bySample$Region=="Arabica"]*ha.m2))

## [1] 0.38 48.69
print("Robusta range:")

## [1] "Robusta range:"
round(range(FD.ds$dht$individuals$bySample$Dhat[FD.ds$dht$individuals$bySample$Region=="Robusta"]*ha.m2))

## [1] 0.38 28.27
  ## Obtaining flock size
# Cluster sizes
print("Forest dependent cluster sizes")

## [1] "Forest dependent cluster sizes"
FD.ds$dht$Expected.S

##      Region Expected.S se.Expected.S
## 1 Arabica    1.535362    0.04194179
## 2 Robusta    1.457918    0.03300256
## 3 Total      1.498419    0.02714972

```