

Supplementary tables for:

Does food abundance explain altitudinal migration in a tropical frugivorous bird?

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Table S1

Contents of 257 fecal samples collected from White-ruffed Manakins (*Corapipo altera*) in 2004 from three elevations in NE Costa Rica; 750 m in the breeding range, and two elevations below the breeding range (300 m and 100 m). I analyzed all fecal samples from elevation-month combinations during which I collected 10 or fewer fecal samples. At sites during months in which I collected > 10 samples, I analyzed 10–38 samples, attempting to equally represent different sex and age classes. Samples are ordered by elevation then by month with the % of fecal matter represented by arthropod remains listed first, followed by presence/absence of seeds from each plant species or morphospecies. Full species names and authorities for the names abbreviated in table columns are as follows (grouped by plant family): AQUIFOLIACEAE; IlexMaxi, *Ilex maxima* W. J. Hahn; ARACEAE; AnthBake, *Anthurium bakeri* Hook. f.; AnthClav, *Anthurium clavigerum* Poepp.; AnthObtu, *Anthurium obtusilobum* N/D; AnthSche, *Anthurium scherzianum* Schott; ARALIACEAE; ShefNica, *Schefflera nicaraguensis* (Standl.) A. C. Sm.; ShefSyst, *Schefflera systyla* (D. J. Smith) Viguiier; ARECACEAE; GeonFerr, *Geonoma ferruginea* H. Wendl. ex Spruce; CECROPIACEAE; CousParv, *Coussapoa parviceps* Standl.; CHLORANTHACEAE; HedyBonp, *Hedyosmum bonplandianum* Kunth.; HedyCost, *Hedyosmum costaricense* C. Wood; HedyScab, *Hedyosmum scaberrimum* Standl.; CLUSIACEAE; ClusSten, *Clusia stenophylla* Standl.; DILLENIACEAE; PinzCori, *Pinzonia coriacea* Mart. & Zucc.; ERICACEAE; CaveCapi, *Cavendishia capitulata* Donn. Sm.; EUPHORBIACEAE; TetrEury, *Tetrochidium euryphyllum* Standl.; GESNERIACEAE; BeslColu, *Besleria columnoides* Hanst.; BeslRobu, *Besleria robusta* Donn. Sm.; BeslSola, *Besleria aff. solanoides* Kunth.; MARCGRAVIACEAE; MarcCaud, *Marcgravia caudata* Triana & Planch.; MarcPitt, *Marcgravia pittieri* Gilg.; MELASTOMATACEAE; BlakTube, *Blakea tuberculata* Donn. Sm.; ClidClan, *Clidemia clandestina* Almeda; ClidDens, *Clidemia densiflora*

(Standl.) Gleason; ClidDisc, *Clidemia discolor* (Triana) Cogn.; ClidEpip, *Clidemia epiphytica* (Triana) Cogn.; ClidJapu, *Clidemia japurensis* DC.; ClidOmbr, *Clidemia ombrophila* Gleason; ClidSp1, *Clidemia* sp.1; ConoMicr, *Conostegia micrantha* Standl.; ConoOers, *Conostegia oerstediana* O. Berg ex Triana; ConoRufe, *Conostegia rufescens* Raudin; ConoXala, *Conostegia xalapensis* (Bonpl.) D. Don; HenrTube, *Henriettea tuberculosa* (Donn. Sm.) L. O. William; LeanLong, *Leandra longicoma* Cogn.; MicoArge, *Miconia argentea* (Sw.) DC.; MicoCalo, *Miconia calocoma* Almeda; MicoCent, *Miconia centrodesma* Naudin; MicoGrac, *Miconia gracilis* Triana; MicoHamm, *Miconia hammelii* (sp. nov.); MicoImpe, *Miconia impetolaris* (Sw.) D. Don; MicoLigu, *Miconia ligulata* Almeda; MicoLore, *Miconia loreyoides* Triana; MicoMult, *Miconia multiplinervia* Cogn.; MicMults, *Miconia multispicata* Naudin; MicoSerr, *Miconia serrulata* (DC.) Naudin; MicoSimp, *Miconia simplex* Triana; Indet59; *Miconia* sp.; OssaBren, *Ossaea brenesii* Standl.; OssaLaxi, *Ossaea laxivenula* Wurdack; OssaMacr, *Ossaea macrophylla* (Benth.) Cogn.; OssaMicr, *Ossaea micrantha* (Sw.) Macfad.; OssaRobu, *Ossaea robusta* (Triana) Cogn.; Indet53 (ABXXX); MONIMIACEAE; SipaTeca, *Siparuna tecaphora* (Poepp. & Endl.) A. DC.; MORACEAE; FicuColu, *Ficus colubrinae* Standl.; NYCTAGINACEAE; NeeaAmpl, *Neea amplifolia* Donn. Sm.; NyctSp?; RUBICACEAE; GuetCris, *Guettarda crispiflora* Vahl.; HamePate, *Hamelia patens* Jacq.; PaliGome, *Palicourea gomezii* C. M. Taylor; PsycCoop, *Psychotria cooperi* Standl.; PsycElat, *Psychotria elata* (Sw.) Hammel; PsycHisp, *Psychotria hispidula* Standl. Ex Steyerm.; PsycLuxu, *Psychotria luxurians* Rusby; PsycMicr, *Psychotria microbotrys* Ruiz ex Standl.; PsycOffi, *Psychotria buchtienii* Standl.; SabiPana, *Sabicea panamensis* Wernham; Indet62; Indet63; Indet64; SOLANACEAE; WithSola, *Witheringia solanacea* L'Hér; ZINGIBERACEAE; Indet60; Unknown Family; Indet36; Indet38; Indet65; Indet66.

Table S2

Summary of fruiting parameters, the number of marked individuals, density/ha for all plant species I marked to quantify fruit abundance at each of my three study sites. Sites are represented by the elevation at which they are located; the 100 m site was on the property of the La Selva Biological Station, the 300 m site was in Braulio Carrillo National Park near the “Cantarrana” refuge, and the 750 m site was in the Rara Avis reserve.

species	min. reproto. size ¹	in <i>C. altera</i> diet? ²	<i>n</i> marked individs.			density/ha ³			mean (SE) fruit production rate ⁴			max mean production rate (month) ⁵		
			100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m
Melastomataceae														
<i>Clidemia densiflora</i> (Standl.) Gleason	0.7	yes	8	6	0	33	30	0	2.6 (0.7)	7.8 (2.6)		7.2 (Dec)	26.1 (Dec)	
<i>Clidemia hammelii</i> Almeda	1	no	0	3	0	0	70	0		2.0 (1.2)			11.2 (Oct)	
<i>Clidemia ombrophila</i> Gleason	1	yes	2	3	0	2	2	20	14.7 (7.6)	3.8 (1.9)		63.3 (Sep)	20.2 (Mar)	
<i>Conostegia cf bracteata</i>	2	no	6	1	0	2	2	0	1.1 (0.2)	1.3 (0.6)		1.3 (Jul)	5.4 (Oct)	
<i>Conostegia lasciopoda</i> Benth	5.5	no	0	3	0	7	2	0		5.6 (0.2)			5.7 (Aug)	
<i>Conostegia micrantha</i> Standl.	3.5	yes	8	5	14	2	2	80	6.2 (0.8)	9.4 (4.8)	27.5 (16.0)	6.9 (Jun)	17.7 (Jun)	71.8 (Jul)
<i>Conostegia rhodopetala</i> Donn. Sm.		no	0	0	1	0	0	2						
<i>Conostegia rufescens</i> Raudin	1.1	yes	0	4	8	0	90	530		8.5 (2.9)	1.4 (1.1)		12.6 (Dec)	4.7 (Nov)
Melastomataceae sp. 1	7.8	no	1	0	0	2	0	0						
<i>Graffenrieda galleotii</i> (Naudin) L. O. Williams	2	no	0	3	0	20	10	0		2.4 (1.3)			5.8 (Nov)	

species	min. repro. size ¹	in <i>C. altera</i> diet? ²	<i>n</i> marked individs.			density/ha ³			mean (SE) fruit production rate ⁴			max mean production rate (month) ⁵		
			100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m
<i>Henriettea tuberculosa</i> (Donn. Sm.) L. O. William	2.5	yes	14	6	6	47	30	40	20.1 (11.0)	5.8 (3.2)	8.9 (5.9)	94.2 (Jun)	25.3 (May)	38.0 (Jun)
<i>Leandra grandifolia</i> Cogn.	1.6	no	0	1	0	0	2	0		9.5 (4.1)			17.0 (Nov)	
<i>Miconia affinis</i> DC.		no	1	0	0	2	0	0						
<i>Miconia appendiculata</i> Triana		no	3	1	0	2	2	0						
<i>Miconia dorsiloba</i> Gleason	2	no	0	5	0	0	10	0		0.6 (0.4)			2.8 (Oct)	
<i>Miconia gracilis</i> Triana	2	yes	6	5	8	2	10	2	2.3 (1.3)	4.2 (2.7)	0.9 (0.9)	6.6 (Jul)	18.7 (May)	2.7 (May)
<i>Miconia grayumii</i> Alameda	3.9	no	1	0	0	2	0	0	46.2 (16.0)			145.8 (Feb)		
<i>Miconia ligulata</i> Alameda	2	yes	0	2	0	0	40	0						
<i>Miconia loreyoides</i> Triana	2	yes	0	0	1	0	0	20			0.4 (0.2)			1.0 (Apr)
<i>Miconia multispicata</i> Naudin		yes	0	2	0	0	2	0						
<i>Miconia nervosa</i> (J. E. Sm.) Triana	1	no	4	1	0	13	2	0	0.3 (0.1)	3.1 (1.3)		0.4 (Apr)	4.4 (Apr)	
<i>Miconia simplex</i> Triana	1.3	yes	6	3	0	27	40	0	0.8 (0.6)	2.0 (1.5)		3.6 (Dec)	15.0 (Nov)	
<i>Miconia</i> sp. G		no	1	0	0	2	0	0						
<i>Ossaea brenesii</i> Standl.	2.3	yes	0	0	1	0	0	30			0.4 (0.1)			0.9 (Oct)
<i>Ossaea macrophylla</i> (Benth.) Cogn.	0.9	yes	6	5	7	7	210	40	0.4 (0.4)	4.7 (1.4)	1.9 (0.9)	2.1 (Aug)	15.8 (Oct)	5.7 (Dec)
<i>Ossaea robusta</i> (Triana) Cogn.	1.5	yes	1	0	8	2	0	150	17.3 (7.9)		10.6 (3.5)	68.4 (Aug)		40.3 (Oct)
Rubiaceae														
<i>Coussarea talamancana</i> Standl.	4.9	no	0	3	0	7	20	0		0.1 (0.1)			0.7 (Jul)	

species	min. repro. size ¹	in <i>C. altera</i> diet? ²	<i>n</i> marked individs.			density/ha ³			mean (SE) fruit production rate ⁴			max mean production rate (month) ⁵		
			100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m	100 m	300 m	750 m
<i>Palicourea gomezii</i> C. M. Taylor	3.5	yes	0	0	7	0	40	20			1.1 (0.2)			2.7 (Mar)
<i>Psychotria acuminata</i> Benth.	2.2	no	1	0	0	2	0	0	1.0 (0.4)			3.3 (Feb)		
<i>Psychotria buchtienii</i> Standl.	0.7	yes	6	0	10	100	20	280	0.3 (0.2)		0.7 (0.2)	1.9 (Mar)		1.9 (Jul)
<i>Psychotria elata</i> (Sw.) Hammel	1	yes	0	0	2	13	160	270			0.5 (0.4)			0.9 (Oct)
<i>Psychotria hispidula</i> Standl. Ex Steyerm.	1.6	yes	0	1	0	0	10	0		1.5 (1.3)			8.1 (Oct)	
<i>Psychotria microbotrys</i> Ruiz ex Standl.	1.2	yes	0	1	1	7	2	10		16.1 (1.4)	1.5 (1.4)		16.1 (Oct)	7.2 (Nov)
<i>Psychotria suerrensii</i> Donn. Sm.	1	no	4	8	0	67	90	0	0.2 (0.1)	0.1 (0.0)		0.5 (Sep)	0.3 (Nov)	
<i>Rudgea cornifolia</i> (Kunth) Standl.	4.7	no	1	0	0	2	0	0						

¹ I estimated the minimum size at which a species is reproductive by three sets of measurements (basal diameter, diameter at breast height, and height of tree) for all marked individuals of a species and all individuals entering into plant transects (see text for details). I also noted for each individual if it was in bud, flower, or fruit. I chose the best predictor of reproductive status by conducting three sets of logistic regression analyses. Because basal diameter was more strongly correlated with reproductive status than either dbh or tree height, I used basal diameter (cm) as my measure of minimum reproductive size. I then searched all records of plants from all sites for each species for the smallest individual found flowering or fruiting and used this as my minimum reproductive

size for the species as a whole.

² I marked individuals of some plant species that I never subsequently found in fecal samples of White-ruffed Manakins (*C. altera*). I restricted my analyses to those species whose seeds appeared in the 283 fecal samples (Table S1) collected during 2004 that I examined.

³ I calculated density of reproductive-sized individuals per ha for each marked plant species at each site by conducting 10–15 0.01 ha belt transects. I located transects ≥ 100 m from each other, and noted the species, basal diameter, dbh (if relevant) and height of all individuals ≥ 1 m tall of all species in the families Melastomataceae and Rubiaceae. I used the summed densities in these transects to estimate densities per ha. I arbitrarily assigned values of 2 individuals/ha to species I marked at a site but that occur in such low densities that they did not enter into transects at that site.

⁴ Mean production rate represents the average daily production rate of ripe fruits for all individuals bearing fruit in a given month at a site, averaged over all fruiting months for the species.

⁵ Maximum production rate is the highest monthly mean production rate (and the month in which that maximum occurred) calculated by taking the average rate of all individuals bearing fruit in a given month.

Table S3

Mean mass and sample contents of 276 sweep samples from three sites during 2004. I excluded ants and termites as well as taxa belonging to orders that characteristically inhabit soil and decaying wood (orders on the right side of the table) as these taxa are not potential prey of White-ruffed Manakins (*Corapipo altera*).

	N samples	mean (SE) sample mass	<i>n</i> individuals of orders included in analyses																	<i>n</i> individuals, excluded orders															
			Arachnida (Aranae)	Arachnida (non-Aranae)	Chilopoda	Colembola	Coleoptera	Diptera	Dermoptera	Dictyoptera	Diplopoda	Ephemeroptera	Hemiptera	Homoptera	Hymenoptera (non-Formicidae)	Larvae and eggs	Lepidoptera	Neuroptera	Odonata	Orthoptera	Phasmida	Thysanoptera	Thysanura	unknown	Diplura	Hymenoptera (Formicidae)	Isopoda	Isoptera	Phthiraptera	Psocoptera	Siphonaptera	Zoraptera			
La Selva, 100 m																																			
Feb	10	0.374 (0.174)	40	3		27	10	2	4		1	13	12	8		1	23	2		2	8		21	1	3										
Mar	10	0.194 (0.079)	17	4	2	45	21	4	10		15	7	7	9	1		3	13	3		11		107	2	2	1									
Apr	10	0.173 (0.031)	48	4	1	46	63	13	13		20	23	19	3	2		3	14			17		30	3											
May	9	0.107 (0.029)	14	8		20	8	2	5		1	3	5	1	1			4			14		19												
Jun	2	0.092 (0.08)	4			4	2				1										5					3									
Jul	10	0.216 (0.057)	29	8	1	67	33	15	4		1	4	22	29	7	5	1		11	1		15		21	2										
Aug	8	0.167 (0.049)	15	4		22	3		3		11	2	2	3					3	2		5		11		15									

		<i>n</i> individuals of orders included in analyses														<i>n</i> individuals, excluded orders																		
	N samples	mean (SE) sample mass	Arachnida (Aranae)	Arachnida (non-Aranae)	Chilopoda	Colembola	Coleoptera	Diptera	Dermoptera	Dictyoptera	Diplopoda	Ephemeroptera	Hemiptera	Homoptera	Hymenoptera (non-Formicidae)	Larvae and eggs	Lepidoptera	Neuroptera	Odonata	Orthoptera	Phasmida	Thysanoptera	Thysanura	unknown	Diplura	Hymenoptera (Formicidae)	Isopoda	Isoptera	Phthiraptera	Psocoptera	Siphonaptera	Zoraptera		
Sep	8	0.274 (0.126)	23	10		26	22	1	10				21	10	4	4				14	1			13		32	1	4						
Oct	10	0.546 (0.191)	54	11	1	37	49		7				14	13	16	6	3			24	4	1		18		55	7	1						
Nov	9	0.37 (0.148)	39	15	1	1	45	24	1	12			13	10	15	6	5			20	2			16		59	4	10		1	1	1		
Dec	6	0.22 (0.087)	20	6			22	19	1	6			6		14	5	2			10	2			5	1	10	5	1						
Cantarrana, 300 m																																		
Jan	9	0.190 (0.050)	43	6	1		65	29	12	1			2	28	22	3				27	1			4		18								
Feb	9	0.138 (0.033)	16	1	2	1	23	5	1	3			2	4	7	5	1			20		1		4		7	1							
Mar	10	0.229 (0.065)	52	12			43	27	9	7				21	19	8	7		1	31	5			11		49	1							
May	8	0.075 (0.041)	12	7			13	12	2	2			1	9	5	4	1			9				2		23	1							
Jun	10	0.272 (0.099)	44	15	1		59	46	14	15			17	29	20	12	4			31	1			10		54	4							
Jul	7	0.296 (0.116)	24	4			27	15	6	3	1		6	21	12	10				10				11		45	4							
Aug	7	0.175 (0.061)	17	4	1		26	7	1	4			3	10	2	4	1			11	1			6		2	1							

		<i>n</i> individuals of orders included in analyses																	<i>n</i> individuals, excluded orders													
	N samples	mean (SE) sample mass	Arachnida (Aranae)	Arachnida (non-Aranae)	Chilopoda	Colembola	Coleoptera	Diptera	Dermoptera	Dictyoptera	Diplopoda	Ephemeroptera	Hemiptera	Homoptera	Hymenoptera (non-Formicidae)	Larvae and eggs	Lepidoptera	Neuroptera	Odonata	Orthoptera	Phasmida	Thysanoptera	Thysanura	unknown	Diplura	Hymenoptera (Formicidae)	Isopoda	Isoptera	Phthiraptera	Psocoptera	Siphonaptera	Zoraptera
Sep	9	0.304 (0.075)	23	10	1	2	26	15	3	8			1	11	6	9	3			10	1			10		377	4					
Oct	10	0.279 (0.117)	36	2			21	12	1	7			9	10	15	2	2			16	1			3	11	73	1	9				
Nov	5	0.074 (0.031)	15	11			4	3		4				13	5	6	1			2	4			3		144	2					
Dec	6	0.084 (0.018)	16	1			18	16	1	3			2	11	18	8	1			6	1			14		103	1	5				
Rara Avis, 750 m																																
Jan	5	0.096 (0.01)	11	1			21	9	3	1		1	1	5	7	2	1			12				1	5	3	4					
Feb	10	0.187 (0.078)	48	7		2	54	29	7	5			12	37	15	3				28	1			6		10	2					
Mar	10	0.061 (0.012)	36	5			31	11	3	6	1		4	14	9	7	1		3	11	1			11		30	2	1	1			
Apr	10	0.209 (0.031)	37	5			56	50	8	16			12	42	24	7	4			27	2			1	23	22	6					
May	8	0.124 (0.058)	16	8	1		35	3	1	1			1	6	5	2	1			4	1			8		6	2					
Jun	6	0.163 (0.071)	14	5			14	9		3			4	5	1	9	1			7	2			3		85	6					

		<i>n</i> individuals of orders included in analyses														<i>n</i> individuals, excluded orders																
	N samples	mean (SE) sample mass	Arachnida (Aranae)	Arachnida (non-Aranae)	Chilopoda	Colembola	Coleoptera	Diptera	Dermoptera	Dictyoptera	Diplopoda	Ephemeroptera	Hemiptera	Homoptera	Hymenoptera (non-Formicidae)	Larvae and eggs	Lepidoptera	Neuroptera	Odonata	Orthoptera	Phasmida	Thysanoptera	Thysanura	unknown	Diplura	Hymenoptera (Formicidae)	Isopoda	Isoptera	Phthiraptera	Psocoptera	Siphonaptera	Zoraptera
Jul	7	0.040 (0.012)	9			8	3	1		1	7	4	1								1	1		5	20					1		
Aug	10	0.121 (0.022)	32	6		46	30	3	3	1		6	11	22	3					22				6	16	5						
Sep	5	0.079 (0.033)	8	6		22	7	6	3					10	2	3				3				3	5	1	1					
Oct	10	0.278 (0.196)	29	4	2	76	20		6	1		15	6	14	6	2				15	1			6	15	2	4					
Nov	9	0.177 (0.075)	22	9		30	13	3	4			15	11	6	35	4				15	2			1	22	2			1			
Dec	5	0.124 (0.029)	23	1	2	51	10	3	1			9	11	11	1					7				8	1	51	3					