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Bananaquit (*Coereba flaveola*) and Orangequit (*Euneornis campestris*) body condition in response to shade coffee habitat in the Blue Mountains of Jamaica

Mckenzie M. Trainor[1], Matthew D. Johnson[2], Herlitz Davis[3]

Abstract Coffee farms can provide habitat for wildlife, but previous research suggests that variation in cultivation practices, especially the amount of shade cover, can affect the body condition of migratory birds. In turn, body condition can carry over to the breeding season and affect reproductive performance. Less work has been done on year-round residents in coffee, and very little is known about how variation in coffee farm vegetation may affect their body condition. We studied the effects of habitat on body condition in two non-migratory songbirds common in Jamaican coffee farms, Bananaquits (*Coereba flaveola*) and Orangequits (*Euneornis campestris*), across five coffee farms in the Blue Mountains of Jamaica. We hypothesized that variation in coffee habitat, especially shade cover, influences body condition of these resident birds. To assess body condition, we ran a principal component analysis on anatomical measurements to obtain a multivariate measure of body size and then performed an ANCOVA to determine if size-adjusted mass differed between farms. Although body condition differed significantly among farms, we found no clear relationships with local habitat features assessed, and the underlying causes for the observed variation in body condition were unclear. Examining landscape characteristics and determining individual survival rates and food availability could give more insight into the underlying reasons for our observed variation in body condition.

Keywords Bananaquit, body condition, *Coereba flaveola*, coffee farms, *Euneornis campestris*, habitat quality, Orangequit, shade grown coffee

Resumen Condición corporal de *Coereba flaveola* y *Euneornis campestris* en respuesta a un hábitat de cafetal de sobra en las Blue Mountains de Jamaica—Las granjas cafetaleras pueden brindar hábitats para la vida silvestre, pero investigaciones previas sugieren que variaciones en las prácticas de cultivo, especialmente en la cantidad de sombra, puede afectar la condición corporal de las aves migratorias. A su vez, esta condición corporal se puede mantener hasta la temporada reproductiva y afectar el desempeño reproductivo. Una menor cantidad de trabajos se han hecho en especies residentes permanentes en cafetales y es poco lo que se conoce acerca de cómo la variación en la vegetación de cafetales puede afectar la condición corporal de estas especies. Estudiamos los efectos del hábitat en la condición corporal de dos paseriformes no migratorias muy comunes en los cafetales jamaiquinos, *Coereba flaveola* y *Euneornis campestris*, en cinco cafetales en las Blue Montains de Jamaica. Nuestra hipótesis es que la variación en los hábitats de cafetales, especialmente en la cantidad de sombra, influye en la condición corporal de estas aves residentes. Para estimar la condición corporal, llevamos a cabo un análisis de componentes principales con las medidas anatómicas para obtener medidas multivariadas del tamaño corporal y llevar a cabo un ANCOVA para determinar si la masa corregida por el tamaño difería entre cafetales. Aunque la condición corporal difirió significativamente entre cafetales, no encontramos una relación clara con las características del hábitat evaluadas y no fueron claras las causas subyacentes de la variación observada en la condición corporal. El examen de las características del paisaje y la determinación de las tasas de supervivencia individuales y la disponibilidad de alimentos pueden dar una visión más clara de las razones subyacentes en la variación observada en la condición corporal.

Palabras clave café de sombra, cafetales, calidad del hábitat, *Coereba flaveola*, condición corporal, *Euneornis campestris*

Résumé La condition corporelle du Sucrier à ventre jaune (*Coereba flaveola*) et du Pique-orange de Jamaïque (*Euneornis campestris*) dans les plantations de café d'ombre des Blue Mountains en Jamaïque—Les plantations de café peuvent fournir un habitat pour la faune, mais des recherches antérieures suggèrent que les variations induites par les pratiques culturales, notamment le taux de couverture ombragée, peuvent affecter la condition corporelle des oiseaux migrateurs. Celle-ci peut ensuite influencer la reproduction et en affecter les performances. Peu de travail a été réalisé sur les oiseaux présents toute l'année dans les plantations de café, et l'influence des

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variations de la végétation de ces plantations sur leur condition corporelle est très peu connue. Nous avons étudié les effets de l'habitat sur la condition corporelle de deux espèces non migratrices communes dans les plantations de café jamaïcaines, le Sucrier à ventre jaune (*Coereba flaveola*) et le Pique-orange de Jamaïque (*Euneornis campestris*), dans cinq plantations des Blue Mountains en Jamaïque. Nous avons émis l'hypothèse que la variation de l'habitat dans ces plantations, en particulier la couverture ombragée, pouvait influencer la condition corporelle des oiseaux sédentaires. Pour évaluer la condition corporelle, nous avons réalisé une analyse en composantes principales sur les mesures anatomiques afin d'obtenir une mesure multivariée de la taille du corps, puis nous avons effectué une analyse de covariance pour déterminer si la masse ajustée à la taille variait selon les plantations. Bien que la condition corporelle soit significativement différente entre les plantations, nous n'avons trouvé aucune relation claire avec les caractéristiques locales de l'habitat évalué. Les causes sous-jacentes des variations de la condition corporelle observées sont donc restées incertaines. L'examen des caractéristiques du paysage ainsi que la détermination du taux de survie individuelle et de la disponibilité alimentaire pourraient donner plus d'informations sur les raisons sous-jacentes des variations de la condition corporelle que nous avons observées.

Mots clés café d'ombre, *Coereba flaveola,* condition corporelle, *Euneornis campestris,* Pique-orange de Jamaïque, plantations de café, qualité de l'habitat, Sucrier à ventre jaune

Increasing global demand for coffee (*Coffea arabica* and *C. canephora*), which is a critical export commodity for developing tropical countries (Rice 1999), threatens forested habitats and leads to fragmentation of previously contiguous landscapes. This land use conversion is important to conservationists as habitat alteration is the largest threat presently facing avian populations (Johnson 2007). However, if farms contain high vegetative biodiversity and are properly managed, they may be able to provide suitable habitat for a wide array of forest-associated species (e.g., Perfecto *et al.* 1996, Greenberg *et al.* 1997, Mas and Dietsch 2004). Shade intensive farms have higher tree densities than sun grown coffee farms and thus provide birds with more abundant food resources such as nectar, fruit, and insects (Sherry 2000).

The quality of habitat that animals choose has important consequences for their fitness (Cody 1985, Johnson 2007) and affects the persistence of entire populations (Lack 1954). An individual's body condition and reproductive capabilities are related to habitat due to spatial variation in available food, roosting, and nesting resources, as well as varying local environmental conditions, such as temperature and precipitation (Bernstein *et al.* 1991, Pulliam 2000). Therefore, ornithologists sometimes use variation in body condition among habitats as a metric for habitat quality (Brown 1996, Strong and Sherry 2000, Johnson *et al.* 2006, Johnson 2007, Benson and Bednarz 2010). For migratory birds spending the non-breeding season in the Caribbean, previous work has shown that variation in habitat can strongly affect body mass (Studds and Marra 2005, Johnson *et al.* 2006), which can in turn 'carry over' into the breeding season and influence reproductive output (Norris *et al.* 2004). The effects of coffee habitat on body condition have been previously studied in several migratory bird species such as Swainson's Warblers (*Limnothlypis swainsonii*; e.g., Strong and Sherry 2001), American Redstarts (*Setophaga ruticilla*; e.g., Wunderle and Latta 2000, Johnson *et al.* 2006), and Cerulean Warblers (*Setophaga cerulea*; e.g., Bakermans *et al.* 2009), but comparatively less research has been conducted on year-round resident birds in coffee. Evidence suggests that relatively few resident species breed within coffee farms (Tejada-Cruz and Sutherland 2004), but many use coffee seasonally, including both Bananaquits (*Coereba flaveola*) and Orangequits (*Euneornis campestris*) in Jamaica (Wunderle *et al.* 1992, Johnson *et al.* 2010). How variation in coffee habitat may affect body condition in these non-migratory species has not been examined, but could have important implications for their demography in landscapes with increasing coffee cover. It is hypothesized that shade trees on coffee farms enhance habitat quality by providing food for insectivorous and nectarivorous birds (Wunderle and Latta 1998, Johnson 2000). To address this hypothesis, we studied the body condition of Bananaquits and Orangequits on five coffee farms in Jamaica's Blue Mountains, where the expansion of coffee is a premier conservation concern (Chai *et al.* 2009).

Table 1. Vegetation characteristics and elevation of five coffee farms in the Blue Mountains of Jamaica.

Farm	Study Plot Size (ha)	% Canopy Cover (Shade)	Tree Density (Tree/ha)	% Coffee Cover	Elevation (m)	Geographic Location
Abbey Green Farm	3.9	42.6	125	43.0	1,360–1,380	18°02'54.01"N, 76°36'21.79"W
Forres Park Farm	4.0	48.1	92	35.5	730–750	18°01'37.70"N, 76°39'36.41"W
Ramble Arnold Farm	4.2	89.0	312	34.8	370–390	17°58'48.72"N, 76°37'46.76"W
Ramble Hutchinson Farm	3.7	51.1	144	47.5	820–840	17°57'59.22"N, 76°34'51.44"W
Whitfield Hall Farm	3.8	59.8	79	36.5	1,250–1,270	18°02'53.46"N, 76°37'07.11"W

Methods

Study Sites

The Blue and John Crow Mountains, located in eastern Jamaica, consist of dense mountain rainforests and cloud forests interspersed with coffee farms, cultivated gardens, grassy slopes, and rural housing. We surveyed and analyzed the avifauna at five coffee farms along shade and elevation gradients: Abbey Green Farm, Forres Park Farm, Ramble Arnold Farm, Ramble Hutchinson Farm, and Whitfield Hall Farm. Two of the farms, Abbey Green and Whitfield Hall, were located at high elevations and consequently experienced slightly different climates than the other three farms (Table 1; Davis 2013).

The amount of shade at each farm was indexed based on vegetation surveys by Davis (2013) in the winter of 2010. Vegetation surveys were conducted to measure shade cover, shade tree density, and coffee cover at 10 points randomly selected using alpha-numeric grid networks established on each farm. Shade cover was estimated with a densiometer, with four readings at each point. Shade tree density was estimated at each point using the point centered quarter method (Mueller-Dombois 1974), which involves estimating tree density using distances to nearest trees from randomized sampling locations. Coffee cover was visually estimated to the nearest 10 % in a 10 × 10 m plot centered on each point. Values of these measurements for each variable were averaged over all 10 points on a farm to obtain measures of vegetation for each farm. Elevation of each farm was determined with a global positioning unit (Garmin eTrex® 10, Garmin Ltd., Olathe, KS).

Bird Surveys

Bird surveys were conducted in the non-breeding season (winter), December 2010 to January 2011. We set up 13–15 12 m mist nets for 5–6 hours per day, for three days at each farm. Bananaquits and Orangequits were measured for culmen and tarsus lengths (to nearest 0.1 mm using electronic calipers), unflattened wing chord (nearest mm with a wing rule), tail length (nearest mm with a ruler), and body mass to the nearest 0.1 g using an Ohaus electronic scale (OHAUS Corp., Parsippany, NJ). To ensure that we did not measure the same bird twice, we clipped the outer 1 cm of an outer tail feather to identify recaptured birds.

Analysis

All data were normally distributed, so we used parametric tests to maximize statistical power for our relatively low samples sizes. To create an index of body condition in Bananaquits and Orangequits, we first performed a principal component analysis (PCA) for each species to obtain one size variable (the first principal component [PC1]) from the four body measurements (culmen, tail, tarsus, and wing). For each species, we then ran an analysis of covariance (ANCOVA), with PC1 as a covariate, to test for the effect of farm on individuals' body mass adjusted for body size. This body mass adjusted for body size was used as a measure of body condition (García-Berthou 2001), and we made the explicit assumption that individuals with a large mass for their given size were in better body condition than birds with a small mass for their size. Some authors have adjusted for body size by testing the residuals of a body size-body mass regression, or used a simple body mass/body size quotient. However, use of ANCOVA is more appropriate because it is specifically designed to test for differences between group means (e.g., mass between farms) when it is known that an extraneous continuous variable (e.g., body size) affects the continuous response variable (García-Berthou 2001). Though limited by a small sample size of farms (n = 5), we examined potential relationships between body condition and farm habitat by computing correlation coefficients (Pearson's r) for size-adjusted body mass versus each of our four habitat variables: shade cover, shade tree density, coffee cover, and mean elevation. All statistical tests were performed in SPSS 19.0 (IBM 2010), and a power analysis was performed with PASS 12.0 (Hintze 2013) to determine what effect size of shade cover on body mass we could detect given the size of and variation in our dataset.

Table 2. First principal component loadings for anatomical measurements of Bananaquits (n = 142) and Orangequits (n = 216) captured at five coffee farms in the Blue Mountains of Jamaica.

Variable	Bananaquit	Orangequit
Culmen	0.578	0.512
Tail	0.833	0.865
Tarsus	0.461	0.444
Wing	0.862	0.884

Results

The five farms varied in vegetation and elevation (Table 1). The amount of coffee coverage was relatively constant among farms indicating that the farms had comparable agricultural efforts (Table 1). There were no statistically significant correlations among any of the habitat variables among the five farms.

In total, 142 Bananaquits and 216 Orangequits were captured among the five farms. PC1 explained 49 % of the variation in anatomical measurements for both Bananaquits and Orangequits (eigenvalue$_{PC1}$ = 1.98 and eigenvalue$_{PC1}$ = 1.99, respectively). All variables loaded positively with PC1, suggesting that it represents overall size of the bird (Table 2). As expected, there were strong positive relationships between PC1 and mass for both species (Table 3).

ANCOVA indicated that both Bananaquit and Orangequit body condition differed significantly among the farms (Fig. 1, Table 3). However, the trends in body condition among farms were not consistent between the two species. Orangequits had the highest observed size-adjusted body mass at Whitfield Hall Farm and the lowest at Forres Park Farm, yet Bananaquits had the highest size-adjusted body mass at Ramble Hutchinson Farm, and the lowest at both Forres Park Farm and Ramble Arnold Farm.

Examining potential relationships between body condition and farm habitat revealed few clear patterns, though for this analysis the sample unit is the farm, so we had little statistical power. A power analysis indicated that, with our sample size and variation in body condition and shade cover, we could de-

Table 3. ANCOVA statistics for body mass (response variable) adjusted for body size (covariate PC1) for Bananaquits and Orangequits in five coffee farms in the Blue Mountains of Jamaica.

Species	Source	df	Sum of Squares	Mean Square	*F*	*P*
Bananaquit	PC1 (covariate)	1	1.89	1.89	6.12	0.015
	Farm	4	8.08	2.02	6.56	< 0.001
	Error	136	27.11	0.31		
	Total adjusted	141	37.26			
	Total	142				
Orangequit	PC1 (covariate)	1	31.96	31.96	35.99	< 0.001
	Farm	4	28.38	7.09	7.99	< 0.001
	Error	210	186.52	0.89		
	Total adjusted	215	243.65			
	Total	216				

tect an effect size (slope) of 0.03 g/percent shade cover with 80 % power. Smaller effect sizes (slopes) could not be detected with our limited number of farms. For both species, size-adjusted body mass was highly variable among farms and was not strongly correlated with shade cover, tree density, or elevation (all $|r| < 0.65$, all $P > 0.25$). We found evidence that size-adjusted body mass tended to increase with increasing coffee cover for Bananaquits ($r = 0.88$, $P = 0.048$). This pattern was not evident for Orangequits ($r = 0.51$, $P = 0.38$).

Discussion

This study is the first to compare body condition of resident birds in coffee farms that vary in shade cover. This is important because body condition in the non-breeding season can affect bird demography (Norris *et al.* 2004). The expansion of coffee threatens Caribbean forests (Chai *et al.* 2009), but some studies suggest that if it is grown with abundant shade cover, it can provide habitat for at least some forest birds, especially migrants (Perfecto *et al.* 1996, Greenberg *et al.* 1997, Mas and Dietsch 2004). Although we found significant differences in body condition of Bananaquits and Orangequits across the farms, the underlying causes of this pattern remain unclear. We hypothesized that variation in coffee habitat, especially shade cover, influences body condition of Bananaquits and Orangequits, but this relationship was not consistently supported by our data. Although Ramble Hutchinson Farm had a relatively high tree density coupled with high size-adjusted masses for both species, Ramble Arnold Farm, which had the highest level of shade and tree density in our study, contained birds that had the second poorest body condition found among the five farms sampled. This inconsistency suggests that the amount of available shade does not reliably influence body condition.

Although the amount of shade on coffee farms did not correlate with varying bird body condition, the types of trees comprising the shade may be of influence. Shade tree species that produce abundant nectar and have high abundances of insects, such as *Inga vera* (Johnson 2000), should help birds maintain good body condition (Johnson *et al.* 2006). In contrast, researchers in India have found that *Grevillea robusta*, which is used on some farms in Jamaica's Blue Mountains, supports fewer birds than other tree species (Anand *et al.* 2008). Also, plant species that are able to produce fruit over extended periods of time provide birds with a reliable and abundant food source (Carlo *et al.* 2004). Both species studied here feed opportunistically on *Citrus* fruits opened by other species (e.g., by woodpeckers or parrots, which are common on our study sites; Brown and Sherry 2006). These nectarivores may benefit commensally from other species on farms with *Citrus* as shade trees (Douglas *et al.* 2013). It is therefore recommended that shade coffee farmers use diverse fruiting plants to increase the effectiveness of avian conservation (Carlo *et al.* 2004).

Abbey Green Farm and Whitfield Hall Farm were located at considerably higher elevations than the other three farms and were associated with birds with larger size-adjusted masses. Birds inhabiting these higher elevations likely experienced a more energetically demanding climate due to an increased amount of rainfall, wind, and lower temperatures, and variation in body mass with elevation has indeed been documented (Blackburn and Ruggiero 2001). In response to stressful environments, animals may use fat reserves to act as energy stores to meet energetic demands (Blem 1990, Bednekoff and Houston 1994). Although this pattern of high elevation grouped with high size-adjusted mass was observed at Abbey Green Farm and Whitfield Hall Farm, the pattern was not consistent with the trends found on other farms. Forres Park Farm and Ramble Hutchinson Farm were similar in elevation, but varied markedly in body condition for both species. Clearly, elevation alone did not consistently affect body condition in our study. Nonetheless, floristic composition and climate vary with elevation, so disentangling the independent effects of these factors remains elusive.

Bananaquit body condition was higher on farms with high coffee cover, especially on Ramble Hutchinson Farm, which had the highest observed coffee cover (Fig. 1, Table 1). This could simply be a spurious result, but could have several possible ecological explanations that may merit further investigation. For example, a high density of coffee shrubs may provide cover from inclement weather or predators which might allow individuals to conserve energy normally expended for thermoregulation or predator avoidance. Alternatively, or perhaps in addition, high coffee

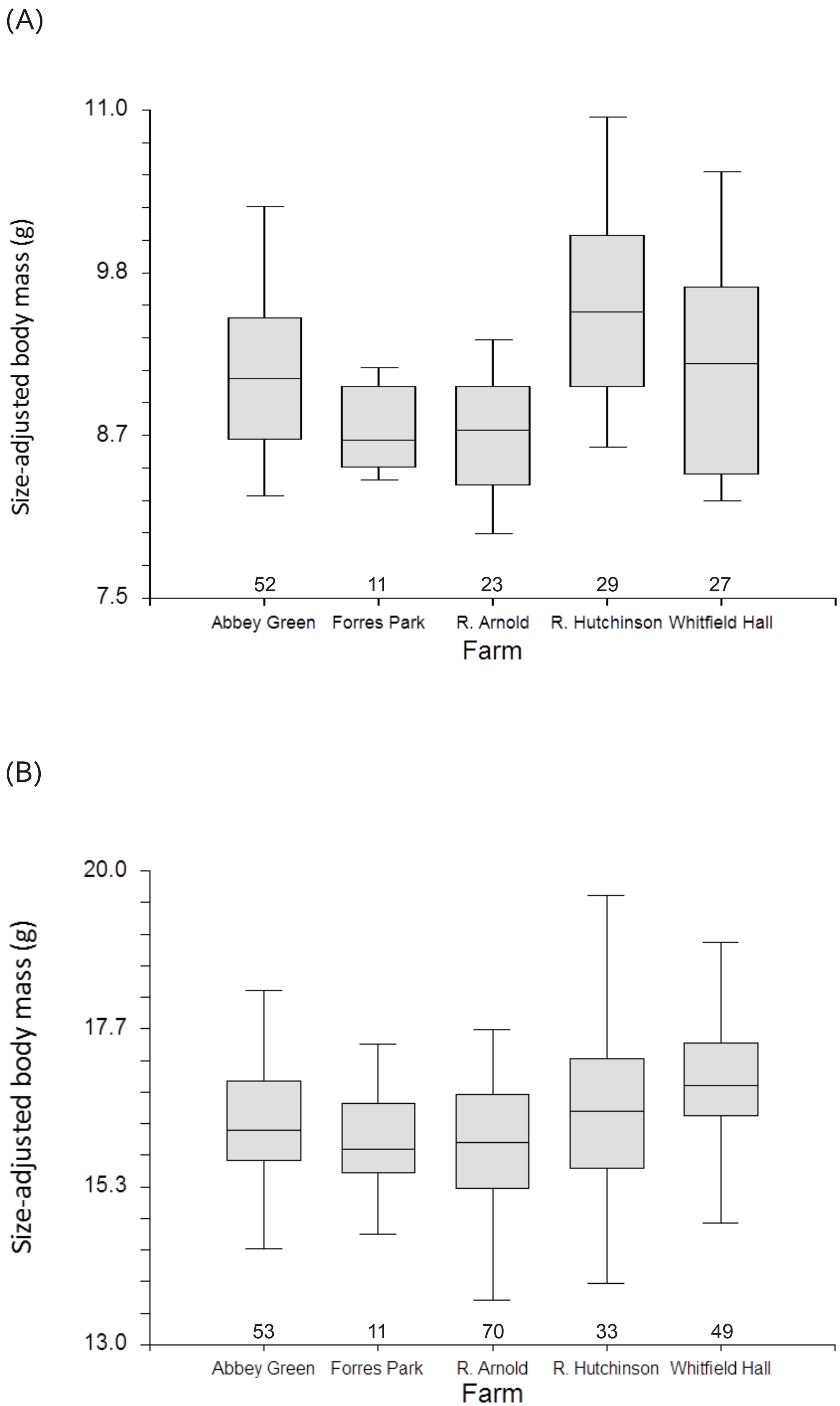

Fig. 1. Box and whisker plots of size-adjusted body mass (g) for (A) Bananaquits (n = 142) and (B) Orangequits (n = 216) found on five coffee farms in the Blue Mountains of Jamaica. Boxes show the first and third quartiles. The band inside the box is the median and the whiskers denote the highest and lowest datum still within 1.5 interquartile range of the upper and lower quartile, respectively. Numbers along the x-axis indicate farm-specific sample sizes.

cover could promote insect prey abundance, an explanation that would not apply as much to the more exclusively nectarivorous Orangequit, which did not exhibit this correlation. Additional research is necessary to better understand whether this pattern is apparent on other coffee farms and to determine underlying ecological factors.

In addition to studying the effects of local habitat on observed variations in body condition, it is important to consider the role of the surrounding landscapes. Other studies have found that tropical resident species depend on both fragmented habitat and the forest matrix surrounding these fragments (e.g., Lovejoy *et al.* 1986, Stouffer and Bierregaard 1995, Gascon *et al.* 1999). Our study showed that while Abbey Green Farm had the lowest amount of shade, it contained birds in good body condition for both Bananaquits and Orangequits (Fig. 1, Table 1). The body condition of these individuals may reflect a combination of the local farm conditions and the surrounding landscape. Abbey Green Farm was located in a remote area, entirely surrounded by intact natural ecosystems protected by the Blue and John Crow Mountains National Park. To better understand the mechanisms behind changes in body condition on different coffee farms, we must simultaneously investigate the available habitat and food resources on the farm, the intact continuous forest in close proximity to the farm, and in the forest patches connecting these areas (Harris 1984, Laurance 1990, 1991, Malcolm 1991). Furthermore, comparing changes in body condition and survival of birds in natural undisturbed forest versus sun and shade coffee farms would offer insight into the effects of alteration of habitat (Johnson *et al.* 2006), and understanding habitat-related variation in body condition may reveal effects on other components of fitness, such as reproductive success (Norris *et al.* 2004).

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Literature Cited

Anand, M.O., J. Krishnaswamy, and A. Das. 2008. Proximity to forests drives bird conservation value of coffee plantations: implications for certification. Ecological Applications 18: 1754–1763.

Bakermans, M.H., A.C. Vitz, A.D. Rodewald, and C.G. Rengifo. 2009. Migratory songbird use of shade coffee in the Venezuelan Andes with implications for conservation of Cerulean Warbler. Biological Conservation 142:2476–2483.

Bednekoff, P.A., and A.I. Houston. 1994. Optimizing fat reserves over the entire winter: a dynamic model. Oikos 71:408–415.

Benson, T.J., and J.C. Bednarz. 2010. Relationships among survival, body condition, and habitat of breeding Swainson's Warblers. Condor 112:138–148.

Bernstein, C.M., J.R. Krebs, and A. Kacelnik. 1991. Distribution of birds amongst habitats: theory and relevance to conservation. Pp. 317–345 *in* Bird Population Studies: Relevance to Conservation and Management (C.M. Perrins, J.D. Lebreton, and G.J.M. Hirons, eds.). Oxford University Press, Oxford, UK.

Blackburn, T.M., and A. Ruggiero. 2001. Latitude, elevation and body mass variation in Andean passerine birds. Global Ecology and Biogeography 10:245–259.

Blem, C.R. 1990. Avian energy storage. Current Ornithology 7:59–113.

Brown, D.R., and T.W. Sherry. 2006. Behavioral response of resident Jamaican birds to dry season food supplementation. Biotropica 38:91–99.

Brown, M.E. 1996. Assessing body condition in birds. Current Ornithology 13:67–135.

Carlo, T.A., J.A. Collazo, and M.J. Groom. 2004. Influences of fruit diversity and abundance on bird use of two shaded coffee plantations. Biotropica 36:602–614.

Chai, S.L., E. Tanner, and K. McLaren. 2009. High rates of forest clearance and fragmentation pre-and post-National Park establishment: the case of a Jamaican montane rainforest. Biological Conservation 142:2484–2492.

Cody, M.L. 1985. Habitat Selection in Birds. Academic Press, New York.

Davis, H. A. 2013. The biological and economic benefits of shade coffee plantations in the Blue Mountain, Jamaica W.I. Ph.D. Thesis. George Mason University, Fairfax, VA.

Douglas, L.R., G. Winkel, and T.W. Sherry. 2013. Does the Bananaquit benefit commensally from parrot frugivory? An assessment using habitat quality. Biotropica 45:457–464.

García-Berthou, E. 2001. On the misuse of residuals in ecology: testing regression residuals vs. the analysis of covariance. Journal of Animal Ecology 70:708–711.

Gascon, C., T.E. Lovejoy, R.O. Bierregaard, Jr., J.R. Malcolm, P.C. Stouffer, H.L. Vasconcelos, W.F. Laurance, B. Zimmerman, M. Tocher, and S. Borges. 1999. Matrix habitat and species richness in tropical forest remnants. Biological Conservation 91:223–229.

Greenberg, R., P. Bichier, and J. Sterling. 1997. Bird populations in rustic and planted shade coffee plantations of eastern Chiapas, Mexico. Biotropica 29:501–514.

Harris, L.D. 1984. The Fragmented Forest: Island Biogeographic Theory and the Preservation of Biotic Diversity. University of Chicago Press, Chicago, IL.

Hintze, J. 2013. PASS 12. NCSS, LLC. Kaysville, UT. www.ncss.com.

International Business Machines (IBM) Corp. 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY.

Johnson, M.D. 2000. Effects of shade-tree species and crop structure on the winter arthropod and bird communities in a Jamaican shade coffee plantation. Biotropica 32:133–145.

Johnson, M.D. 2007. Measuring habitat quality: a review. Condor 109:489–504.

Johnson, M.D., J.L. Kellermann, and A.M. Stercho. 2010. Pest reduction services by birds in shade and sun coffee in Jamaica. Animal Conservation 13:140–147.

Johnson, M.D., T.W. Sherry, R.T. Holmes, and P.P. Marra. 2006. Assessing habitat quality for a migratory songbird wintering in natural and agricultural habitats. Conservation Biology 20:1433–1444.

Lack, D. 1954. The Natural Regulation of Animal Numbers.

Clarendon Press, Oxford, UK.
Laurance, W.F. 1990. Comparative responses of five arboreal marsupials to tropical forest fragmentation. Journal of Mammalogy 71:641–653.
Laurance, W.F. 1991. Ecological correlates of extinction proneness in Australian tropical rain forest mammals. Conservation Biology 5:79–89.
Lovejoy, T.E., R.O. Bierregaard, Jr., A.B. Rylands, J.R. Malcolm, C.E. Quintela, L.H. Harper, K.S. Brown, Jr., A.H. Powell, G.V.N. Powell, H.O. Schubart, and M.B. Hays. 1986. Edge and other effects of isolation on Amazon forest fragments. Pp. 257–285 *in* Conservation Biology: the Science of Scarcity and Diversity (M.E. Soulé, ed.). Sinauer Associates, Sunderland, MA.
Malcolm, J.R. 1991. The Small Mammals of Amazonian Forest Fragments: Pattern and Process. Ph.D. Thesis. University of Florida, Gainesville, FL.
Mas, A.H., and T.V. Dietsch. 2004. Linking shade coffee certification to biodiversity conservation: butterflies and birds in Chiapas, Mexico. Ecological Applications 14:642–654.
Mueller-Dombois, D. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, Inc., New York, NY.
Mundle, M. 2000. Nesting of the Orangequit (*Euneornis campestris*) in Jamaica. El Pitirre 13:91.
Norris, D.R., P.P. Marra, T.K. Kyser, T.W. Sherry, and L.M. Ratcliffe. 2004. Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. Proceedings of the Royal Society. Series B: Biological Sciences 271:59–64.
Perfecto, I., R.A. Rice, R. Greenberg, and M.E. van der Voort. 1996. Shade coffee: a disappearing refuge for biodiversity. BioScience 46:598–608.
Pulliam, H.R. 2000. On the relationship between niche and distribution. Ecology Letters 3:349–361.
Rice, R.A. 1999. A place unbecoming: the coffee farm of northern Latin America. Geographical Review 89:554–579.
Sherry, T.W. 2000. Shade coffee: a good brew even in small doses. Auk:117:563–568.
Stouffer, P.C., and R.O. Bierregaard, Jr. 1995. Use of Amazonian forest fragments by understory insectivorous birds. Ecology 76:2429–2445.
Strong, A.M., and T.W. Sherry. 2000. Habitat-specific effects of food abundance on the condition of Ovenbirds wintering in Jamaica. Journal of Animal Ecology 69:883–895.
Strong, A.M., and T.W. Sherry. 2001. Body condition of Swainson's Warblers wintering in Jamaica and the conservation value of Caribbean dry forests. Wilson Bulletin 113:410–418.
Studds, C.E., and P.P. Marra, 2005. Nonbreeding habitat occupancy and population processes: an upgrade experiment with a migratory bird. Ecology 86:2380–2385.
Tejeda-Cruz, C., and W.J. Sutherland. 2004. Bird responses to shade coffee production. Animal Conservation 7:169–179.
Wunderle, J.M., Jr., D.J. Lodge, and R.B. Waide. 1992. Short-term effects of Hurricane Gilbert on terrestrial bird populations on Jamaica. Auk 109:148–166.
Wunderle, J.M., Jr., and S.C. Latta. 1998. Avian resource use in Dominican shade coffee plantations. Wilson Bulletin 110: 271–281.
Wunderle, J.M., Jr., and S.C. Latta. 2000. Winter site fidelity of Nearctic migrants in shade coffee plantations of different sizes in the Dominican Republic. Auk 117:596–614.

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