ORNITOLOGÍA NEOTROPICAL
(2021) 32: 51–55
SHORT NOTE

MORPHOLOGICAL VARIATION IN THE TIT-LIKE DACNIS (*XENODACNIS PARINA*): A CALL TO REVISE THE TAXONOMIC STATUS OF ECUADOR'S POPULATION

Juan M. Aguilar[1*]

[1] Departamento de Postgrados, Universidad del Azuay, Av. 24 de Mayo 7-77 y Hernán Malo, Cuenca, Ecuador.
E-mail: Juan M. Aguilar · juanmaguilaru@yahoo.com

Abstract · *Xenodacnis* is a specialized high-Andean bird genus in which males are larger and show different coloration from females. However, sexual dimorphism has not been analyzed in detail yet. Distributed in Ecuador and Peru, *Xenodacnis* has long been considered a single-species genus with three subspecies. The population in Ecuador, discovered in the 1980s, has not been given a taxonomic identity so far; thus, this study gathers morphological data from *Xenodacnis* throughout its distribution and confirms the morphological differences between sexes: males are significantly larger and heavier than females, but without consistent differences in bill size. Between populations, the research shows smaller individuals in the south, with size increasing towards the northernmost Ecuadorian populations. These results suggest that the taxonomy of the genus *Xenodacnis* should be revised and the population from Ecuador should have a proper taxonomic identity, different from all previously described members of the genus.

Resumen · Variación morfológica del azulito altoandino (*Xenodacnis parina*): un llamado a revisar el estado taxonómico de la población de Ecuador
Xenodacnis es un género de aves especialistas de los altos Andes, con machos más grandes y con diferentes patrones de coloración de las plumas con respecto a las hembras, pero este dimorfismo sexual no se ha analizado en detalle aún. Distribuido en Ecuador y Perú, *Xenodacnis* ha sido considerado un género con una especie y tres subespecies, pero a la población descubierta en la década de 1980 en Ecuador no se le ha asignado un estado taxonómico. En consecuencia, obtuve información morfológica de *Xenodacnis* a lo largo de su distribución y confirmé las diferencias sexuales: los machos son significativamente más grandes y más pesados que las hembras, pero no hay diferencias significativas en las medidas del pico. El análisis entre poblaciones muestra individuos pequeños al sur, con un incremento en el tamaño hacia la población del norte en Ecuador. Estos resultados sugieren que la taxonomía del género *Xenodacnis* debería ser revisada y que la población de Ecuador debe tener su propia identidad taxonómica, diferente a las de los miembros del género descritos previamente.

Key words: Allopatric speciation · Dimorphism · Discriminant traits · Divergence · Polytypic

INTRODUCTION

Mountain tops of the tropical Andes do not have high bird diversity, but provide habitat for rare species that are often specialized, isolated and threatened by habitat fragmentation (Fjeldså 1993, Donald et al. 2010). The Tit-like Dacnis (*Xenodacnis parina*, Passeriformes: Thraupidae), the only species in the genus, inhabits mountain top ecosystems, in a discontinuous fashion, from southern Peru to central Ecuador (Aguilar 2019, Figure 1). They have a specialized diet consisting of small insects and extra floral nectar, gleaned from beneath the leaves of *Gynoxys* shrubs (Aguilar & Iñiguez 2015). *X. parina* is sexually dimorphic: males are bigger and Prussian blue, with bright blue shaft streaks and dark grey undertail coverts, while females are smaller, less conspicuously colored, with blue on the forecrown, lores, chin and orbital feathers, a ferruginous throat and breast, which becomes pale gray towards the vent and undertail coverts, a conspicuous ashy brown dorsal coloration, and bluish-grey wing feathers (see Schulenberg et al. 2007, Plate 275:5).

X. parina was described in 1873 by Jean Louis Cabanis. The genus is considered as monophyletic and polytypic by most authorities (e.g., Clements et al. 2019, Remsen et al. 2019), as it displays unique genetic characteristics and evolutionary distinctiveness (Funk & Burns 2018). Populations of *X. parina* are isolated and divergent (Bond & de Schauensee 1939, Zimmer & Mayr 1943, Ridgely & Tudor 2009, Hilty 2019), with three described subspecies (Figure 1). The nominal subspecies *X. parina parina* (Cabanis 1873) is found in southern Peru in the Ayacucho, Apurimac, Cuzco and Junín departments, and in a southern isolated population in Arequipa (Aguilar 2019). It is different from the northern populations of the polytypic *petersi* group, as it has two described subspecies: *X. parina bella* (Bond & de Schauensee 1939), from northern Peru in the departments of Amazonas, Cajamarca, and La Libertad, as well as *X. parina petersi* (Bond & de Schauensee 1939) in western central Peru, in the de-

Submitted 16 May 2019 · First decision 13 November 2019 · Acceptance 11 February 2020 · Online publication 12 July 2019
Communicated by Paulo Pulgarín

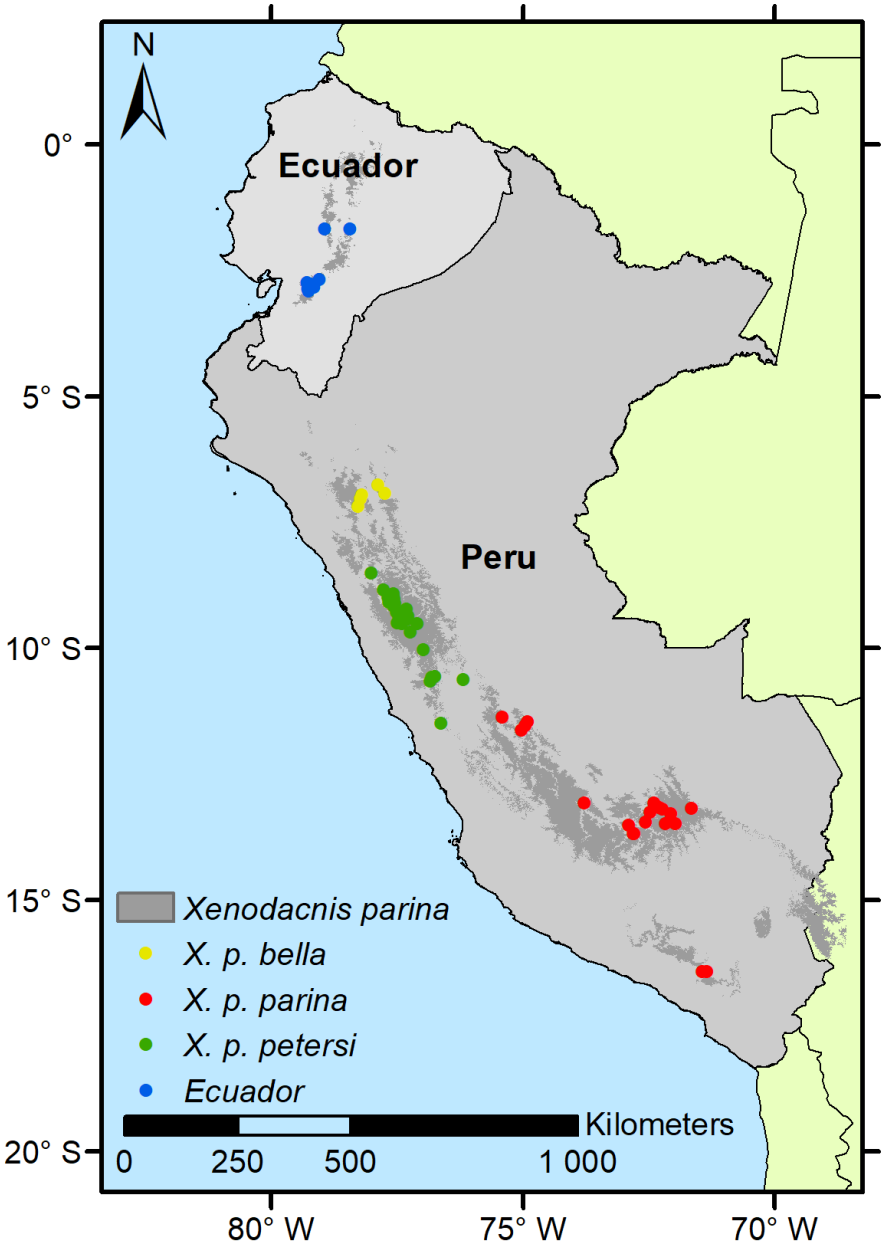

Figure 1. Geographical distribution of subspecies of *Xenodacnis parina* in Ecuador and Peru.

partments of Ancash, Huánuco, and Lima departments. In addition, there is a northern isolated Ecuadorian population of uncertain taxonomic status, found in Azuay, Cañar and Chimborazo provinces (Figure 1). Most likely, this Ecuadorian population is closer to the *petersi* group (Ridgely 1980, del Hoyo & Collar 2019).

The nominal *X. parina parina* is the smallest type. Males lack the streaked pattern, have greenish undertail coverts, while females differ from other populations by having a full blue cape with a duller ferruginous vent. These traits are different from the northern larger individuals of the polytypic *petersi* group (including the Ecuadorian population, *X. parina bella* and *X. parina petersi*. Clements et al. 2019, See Schulenberg et al. 2007, Plate 275:5). Furthermore, Aguilar (2016) analyzed the taxonomic affinities of the Ecuadorian population, described it as a different subspecies, and named this new lineage *Xenodacnis parina cajaensis* subsp. *nov*. (*Páramo* or Cajas Dacnis) after the Cajas Mountain massif, where this population was discovered (Ridgely 1980) and an important area for its conservation (Aguilar 2016).

Here, I analyzed morphological traits obtained from live individuals and museum specimens of *Xenodacnis*. The study describes sexual dimorphism and geographic variations across populations to assess the taxonomic identity of the population from Ecuador as a contribution to clarify the current taxonomy of this Andean genus.

RESULTS

The morphological data was obtained from a sample of 98 *X. parina* individuals, including 21 *X. parina parina*, 23 *X. parina petersi*, 5 *X. parina bella,* and 49 individuals of the Ecuadorian population (Supplementary Table 1). All populations, except for *X. parina bella*, for which sample sizes were very low, showed significant sexual dimorphism, with heavier males having longer wings, tails and tarsi (Figure 2). Bill measurements were similar between sexes (Figure 2).

Results from morphological linear models revealed signif-

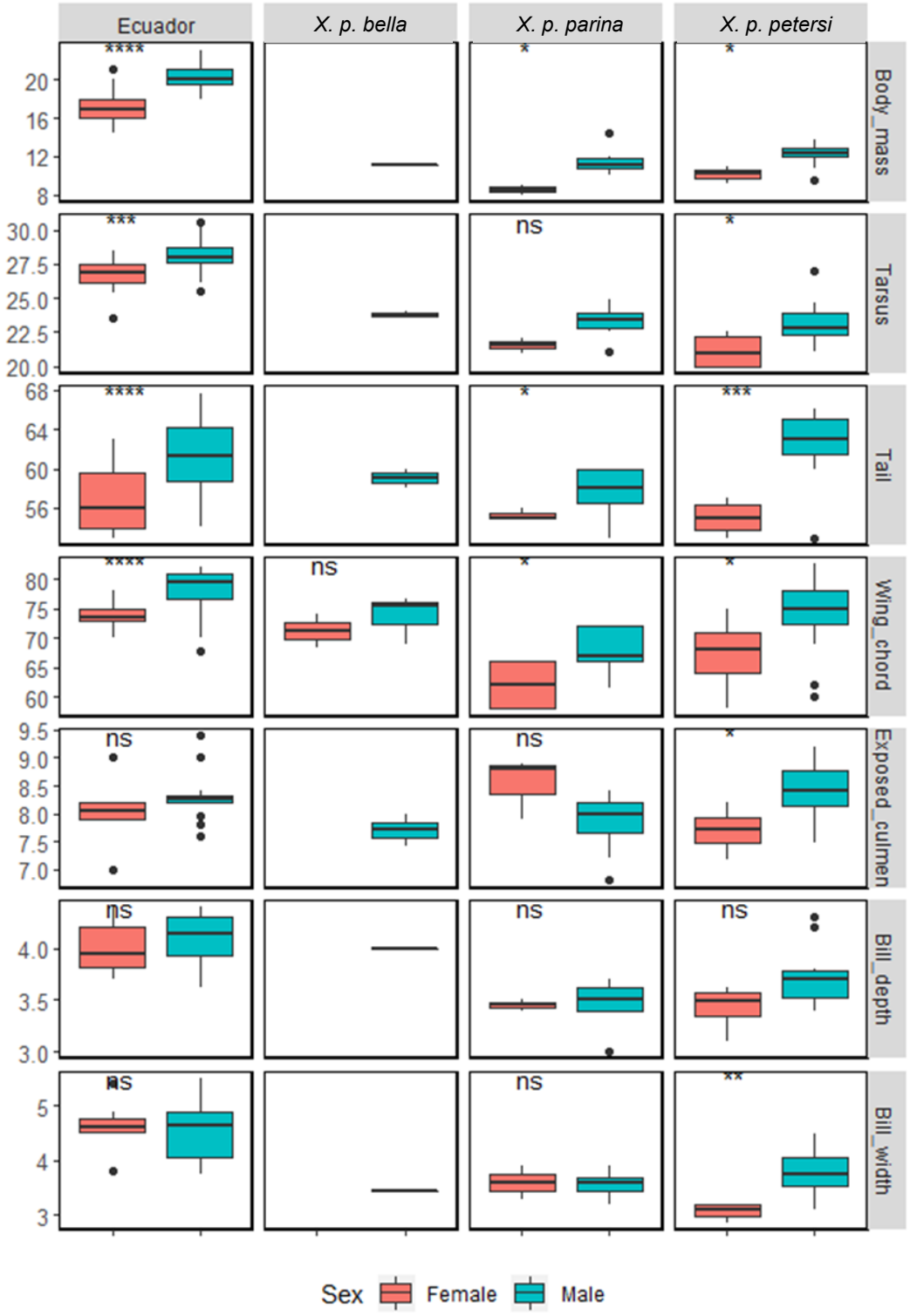

Figure 2. Boxplots of morphological variables of *Xenodacnis* females (red) and males (blue) from different populations in Ecuador and Peru. Each case depicts the statistical support (t-test statistical significance) for sexual dimorphism (n.s. = not significant; **P* < 0.05; ***P* < 0.01; ****P* < 0.001; *****P* < 0.0001).

icant differences between populations (Supplementary Table 2) and a significant sex effect (except for bill measurements) (Supplementary Table 2, Figure 2). The interaction between population and sex was not statistically significant, except in the few cases of bill measurements (Supplementary Table 2).

Linear discriminant analysis for males and females seemed to separate well the different taxonomic entities of the genus *Xenodacnis* (Figure 3). The first linear discriminants emphasized most of the variation, as the Ecuadorian popular tion was clearly discriminated from the Peruvian subspecies, with body mass, tarsus, bill width, and bill depth as important contributors to linear discriminants (Table 1). Bill characteristics were good discriminant traits for the differentiation of the Peruvian subspecies (Table 1). Statistical analysis placed body mass and tarsus length as the best predictors of sex and populations' identity (Table 1, Supplementary Table 2), being good diagnosable characters to consider in further taxonomic revisions of the genus.

Table 1. The first two Linear discriminants (LD1 and LD2) from female and male morphological analysis between different subspecies of *Xenodacnis*. Contribution of each morphological variable to the first two linear discriminants of the analysis.

	LD1-Female	LD2-Female	LD1-Male	LD2-Male
Exposed culmen	-3.5949129	0.7064838	-0.41903956	1.315307
Bill depth	-7.0863465	1.6297071	-1.95639538	0.58466685
Bill width	-9.9837715	-9.1068666	-0.14917287	-0.24930433
Wing chord	-0.4740624	-0.2574447	0.01730247	-0.04561198
Tail	0.9305193	0.7241671	-0.05441921	0.28868863
Tarsus	0.1598943	0.4817375	-0.00768518	-0.51568464
Body mass	1.0932953	1.5582679	-0.71744694	0.10965348

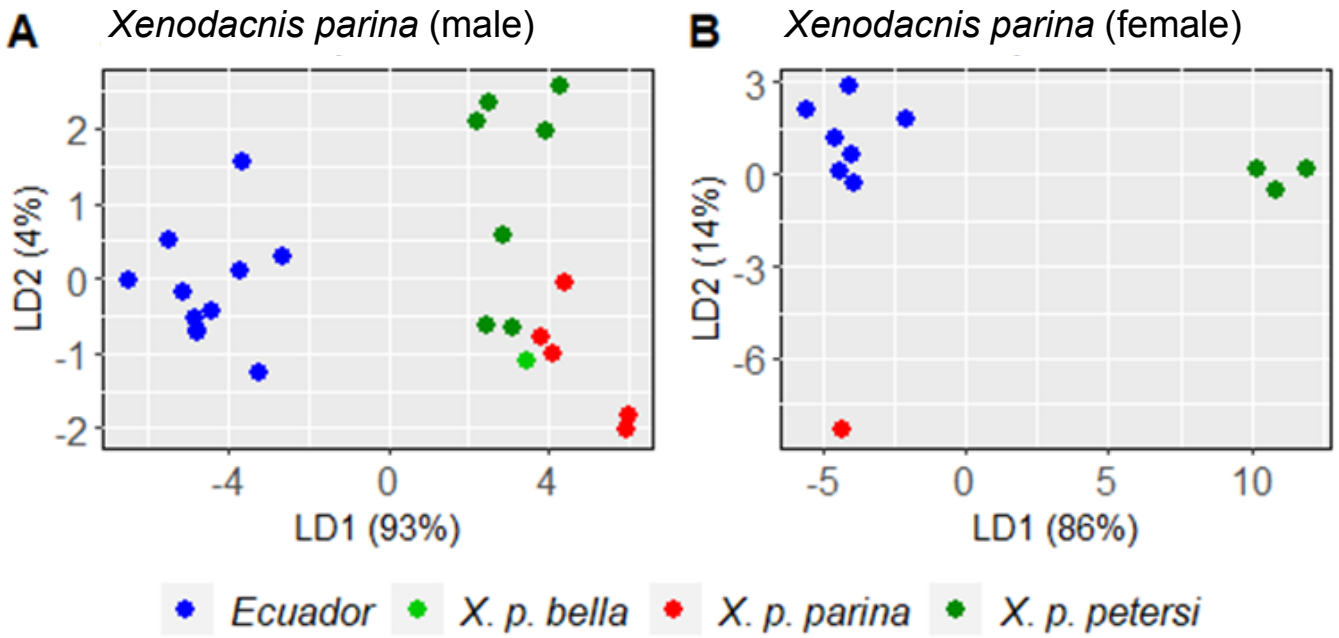

Figure 3. Multivariate morphological space of *Xenodacnis*, based on linear discriminant analyses. The plots depict the first two linear discriminants (LD1 and LD2) based on the analyses of six morphological variables of individuals for which all data was available. A) 24 males, B) 11 females.

DISCUSSION

The analyses of morphological variation within *Xenodacnis* confirmed the existence of substantial sexual dimorphism across all populations (males being generally larger than females), with body mass as the most distinct trait between sexes. The larger males have larger home ranges also (Aguilar & Iñiguez 2015), possibly to meet a higher energetic demand (Cornioley et al. 2017, Töpfer 2018). Bill size was similar for both sexes, except for *X. parina petersi*. The analyses also revealed that *Xenodacnis* individuals from the population in Ecuador are larger and heavier compared to the southern subspecies, thus defining the Ecuadorian population as different from the nominal *X. parina parina*, and also from *X. parina petersi* and *X. parina bella*.

The current knowledge of the monospecific genus *Xenodacnis* evidences two chromatic lineages: the northern polytypic *petersi* group (Ecuadorian population, *X. parina petersi* and *X. parina bella*) and the nominal *X. parina parina* (Bond & de Schauensee 1939, Zimmer & Mayr 1943, Schulenberg et al. 2007). The northern *petersi* group is highly variable in size (Figure 2), as the literature describes a range of body masses (Isler & Isler 1999, Fjeldså & Krabbe 1990), which is still lower than the values for the Ecuadorian population (Table 1). The fact that bill dimensions differed across populations suggests that foraging specialization and a similar diet throughout the distribution (Fjeldså & Krabbe 1990, Aguilar & Iñiguez 2015) have not constrained bill morphology. Wing chord and tail length expressed less variation among body size traits (Table 1, Supplementary Table 2) and both are often age-dependent and seasonally variable (Töpfer 2018); therefore, they are not good diagnosable characteristics.

The existence of the described subspecies is supported by biogeographical Andean barriers, which isolate these populations under different environmental conditions (Aguilar 2019). The Ecuadorian population inhabits shrubby *páramo*, characterized by higher precipitation and temperature, whereas the Peruvian populations inhabit *jalca* and *puna* ecosystems, which are drier, colder, and more seasonal (Aguilar 2019). The analyses also show that individuals from the northern populations are larger than those from southern populations. Our results are not consistent with Bergmann's rule, which states that larger individuals should be found in populations exposed to lower temperatures (James 2018), but follow Allen's rule, which states that in wide-ranging homeotherms, appendages (e.g. tarsus and bill) are smaller under colder climates (Symonds & Tattersall 2010, James 2018).

In conclusion, *X. parina* is a sexual dichromatic and dimor-

phic species that varies in size across a discontinuous geographic distribution. The Ecuadorian population, recently assessed as country-endangered (Freile et al. 2019), should be granted a taxonomic identity within the *petersi* group, different from the nominal *X. parina parina*. However, to fully clarify the taxonomy of *Xenodacnis* we need data from unreached and less known populations, and to perform genetic divergence analyses.

ACKNOWLEDGMENTS

Thanks to Pedro Álvarez, Paul Molina and Xavier Iñiguez for their constant support and comments. To Diego García Olaechea from the Corbidi collection and Mauricio Ugarte at Museo de Historia Natural in Arequipa, who helped with data gathering, and to Andrea Nieto and Bernarda Vásquez for field assistance. This paper was improved by comments from Michael Melampy, Juan F. Freile, and Boris Tinoco. This study was partly funded by EcoCiencia, EcoFondo and PBIC-CTA.

REFERENCES

Aguilar, JM & X Iñiguez (2015) Hábitos alimentarios de *Xenodacnis* (*Xenodacnis parina*) en los páramos del sur del Ecuador. *Ornitología Neotropical* 26: 211–217.

Aguilar, JM (2016) Description and Conservation status of a new subspecies of *Xenodacnis parina* (Aves: Thraupidae) from the Ecuadorian Andes. M.Sc. thesis, Pontificia Universidad Católica del Ecuador, Quito, Pichincha, Ecuador.

Aguilar, JM (2019) Geographic distribution analysis of the genus *Xenodacnis* (Birds: Thraupidae) using ecological niche modeling. *Revista peruana de biología* 26: 317–324.

Bond, J & RM de Schauensee (1939) Description of new species and subspecies of *Xenodacnis*. *Notulae Naturae* 40: 1–2.

Cabanis, J (1873) Ueber *Xenodacnis parina* nov. gen. et spec. des Berliner Museums, von C. Jelski in Peru entdeckt. *Journal für Ornithologie* 21: 311–312.

Clements, JF, TS Schulenberg, MJ Iliff, D Roberson, TA Fredericks, BL Sullivan & CL Wood (2019) *The eBird/Clements checklist of birds of the world: v2016*. Cornell Lab of Ornithology, Ithaca, New York. USA. Available at http://www.birds.cornell.edu/clementschecklist/download/ [Accessed 7 July 2021]

Cornioley, T, S Jenouvrie, L Börger, H Weimerskirch & A Ozgul (2017) Fathers matter: male body mass affects life-history traits in a size-dimorphic seabird. *Proceedings of the Royal Society B: Biological Sciences* 284: 20170397.

del Hoyo, J & N Collar (2019) Streaked Dacnis (*Xenodacnis petersi*). *In* del Hoyo, J, A Elliott, J Sargatal, DA Christie & E De Juana (eds). *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelona, Spain. Available at http://www.hbw.com/node/1344189 [Accessed 30 April 2019]

Donald, PF, NJ Collar, SJ Marsden & DJ Pain (2010) *Facing extinction: the world's rarest birds and the race to save them*. Second Edition. Bloomsbury Publishing plc, Christopher Helm, London, UK.

Fjeldså J, & N Krabbe (1990) *Birds of the high Andes*. Zoological Museum, Univ. of Copenhagen and Apollo Books, Svendborg, Denmark.

Fjeldså, J (1993) The avifauna of the *Polylepis* woodlands of the Andean highlands: the efficiency of basing conservation priori ties on patterns of endemism. *Bird Conservation International* 3: 37–55.

Freile, JF, T Santander, G Jiménez-Uzcátegui, L Carrasco, D Cisneros-Heredia, E Guevara, M Sánchez & B Tinoco (2019) *Lista roja de las aves del Ecuador*. Ministerio del Ambiente, Aves y Conservación, Comité Ecuatoriano de Registros Ornitológicos, Fundación Charles Darwin, Universidad del Azuay, Red Aves Ecuador y Universidad San Francisco de Quito, Quito, Ecuador.

Funk, ER & KJ Burns (2018) Evolutionary distinctiveness and conservation priorities in a large radiation of songbirds. *Animal Conservation* 22: 274–284

Hilty, SL (2019) Tit-like Dacnis (*Xenodacnis parina*). *In* del Hoyo, J, A Elliott, J Sargatal, DA Christie & E De Juana (eds). *Handbook of the birds of the world alive*. Lynx Edicions, Barcelona, Spain. Available at https://www.hbw.com/node/61758 [Accessed 30 April 2019]

Isler, ML & PR Isler (1999) *The tanagers: natural history, distribution, and identification*. Smithsonian Institution Press, Washington, USA.

James, GD (2018) Bergmann's and Allen's Rules. *In* Trevathan, W, M Cartmill, D Dufour, C Larsen, D ORourke, K Rosenberg & K Strier (eds). *The International Encyclopedia of Biological Anthropology*. John Wiley & Sons, Inc. New Jersey, USA.

R Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at http://www.R-project.org/ [Accessed 30 April 2019].

Remsen, JV, JI Areta, CD Cadena, A Jaramillo, M Nores, JF Pacheco, J Pérez-Emán, MB Robbins, FG Stiles, DF Stotz & KJ Zimmer (2019) *A classification of the bird species of South America*. American Ornithologists' Union, Washington, USA. Available at http://www.museum.lsu.edu/~Remsen/SACCBaseline.html [Accessed 30 April 2019]

Ridgely, RS (1980) Notes on some rare or previously unrecorded birds in Ecuador. *American Birds* 34: 242–248.

Ridgely, RS & G Tudor (2009) *Birds of South America. Passerines*. Helm Identification Guides, London, UK.

Schulenberg, TS, DF Stotz, DF Lane, JP O'Neill & TA Parker III (2007) *Birds of Peru*. Princeton University Press, Princeton, New Jersey, USA.

Symonds, MRE & GJ Tattersall (2010) Geographical Variation in Bill Size across Bird Species Provides Evidence for Allen's Rule. *The American Naturalist* 176: 188–197.

Töpfer, T (2018) Morphological Variation in Birds: Plasticity, Adaptation, and Speciation. *In* Tietze D. (ed.) *Bird Species. Fascinating Life Sciences*. Springer, Cham, Switzerland.

Zimmer, J T & E Mayr (1943) New species of birds described from 1938 to 1941. *The Auk* 60: 249–262.