



## HIGHLAND AVIAN SURVEYS IN CERRO HOYA NATIONAL PARK (AZUERO, PANAMÁ) REVEAL NEW RANGE EXTENSIONS, INCLUDING A RARE HUMMINGBIRD (*SELASPHORUS* SP.)

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**Abstract** · Cerro Hoya National Park in Panama (CHNP) is one of the least explored protected areas in southern Mesoamerica. It houses the greatest ecosystem diversity in the degraded Azuero Peninsula, but its inaccessibility hinders expeditions and scientific research. Avian richness in CHNP was previously estimated by combining data from five ornithological expeditions at *ca.* 225 species. However, the highest altitude areas remained relatively unexplored and some historical records were not verified. We intensively surveyed highlands and foothills of CHNP and identified five new range extensions. One of these included a *Selasphorus* sp., of which we collected three male (two adults, one immature) and one female specimens. We compared morphology and plumage color patterns of these with closely related species in detail and confirm their likely classification with the endangered Glow-throated Hummingbird (*Selasphorus ardens*). This species is rare, with few documented sightings, confirmed specimens, and no unambiguous female museum specimen until now. We also confirmed historical records and provide 26 unlisted species (one by an external source) to CHNP. Our results confirm that Cerro Hoya is a highly biodiverse sky-island of Mesoamerica. We urge improved enforcement of its protection in combination with further studies of the ecology and evolutionary processes in this unique region.

**Resumen** · Censos ornitológicos en ambientes de altura en el Parque Nacional Cerro Hoya (Azuero, Panamá) revelan nuevas extensiones de distribución, incluyendo un inusual colibrí (*Selasphorus* sp.)

El Parque Nacional Cerro Hoya (PNCH) es una de las áreas protegidas menos exploradas de Panamá y el sur de Mesoamérica. Este alberga la mayor diversidad de ecosistemas en la degradada península de Azuero, pero su inaccesibilidad dificulta la investigación científica. Combinando datos de cinco expediciones ornitológicas, se estimó una riqueza aviar de alrededor de 225 especies. No obstante, las áreas de mayor altitud permanecieron relativamente inexploradas y algunos registros históricos no fueron verificados. Exploramos intensivamente las tierras altas y estribaciones del PNCH e identificamos cinco nuevas extensiones de distribución. Uno de estos incluye *Selasphorus* sp., del cual colectamos tres especímenes machos (dos adultos, un juvenil) y una hembra. Comparamos detalladamente la morfología y los patrones de coloración del plumaje con especímenes de especies relacionadas estrechamente. Confirmamos que estos individuos podrían pertenecer al amenazado Colibrí Ardiente (*Selasphorus ardens*). Esta especie es rara, con pocos avistamientos y especímenes de museo con información inconsistente, principalmente en hembras. También confirmamos los registros históricos y agregamos 26 especies no listadas para el PNCH (una obtenida por fuente externa). Nuestros resultados confirman que Cerro Hoya es una isla-cielo de gran biodiversidad en Mesoamérica. Es urgente mejorar la aplicación de su protección, así como estudiar la ecología y los procesos evolutivos en esta región única.

**Key words:** Cerro Hoya National Park · Range extension · *Selasphorus* · Species richness · Sky-island

### INTRODUCTION

Isolated mountains surrounded by lowlands are often referred to as sky-islands because they are biogeographically separated from other mountainous regions. Once thought to contain few species due to harsh high-altitude conditions, sky-islands have increasingly been shown to be havens of biodiversity and are often home to endemic species (Coyne & Orr 2004, Cooke 2005, Nogués-Bravo et al. 2008, Steinbauer et al. 2016). One of the most prominent sky-islands of Panama, and Central America overall, is the southern highland region of the Azuero Peninsula, which is contained within Cerro Hoya National Park (CHNP). The park is isolated from the rest of Panama's mountain systems (i.e., Talamanca, Serranía de Tabasará, and Central Cordillera;

Receipt 12 April 2018 · First decision 10 October 2018 · Acceptance 31 May 2019 · Online publication 4 July 2019

Communicated by Raul Ortiz-Pulido & Kaspar Delhey © Neotropical Ornithological Society

Figure 1), which are over 125 km to the north and separated by largely degraded and populated lowlands (Fort et al. 2014, Miller et al. 2015). El Montuoso Forest Reserve, about 46 km north of CHNP (Figure 1) and with lower elevations, contains similar forest but post-logging succession is recent. Forested regions there are not likely linked to CHNP. Habitat diversity in CHNP is the richest of the entire peninsula with a combination of marine coastal habitats, mangrove and tropical lowland wet forests (some heavily deforested; Heckadon-Moreno 2009), and rugged mountains (up to ~ 1600 m a.s.l.) that shelter headwaters for many rivers (Angehr 2003). The park is considered to belong to the Costa Rica-Panama Highlands and southern Central American Pacific Slope Endemic Bird Areas. It is classified as an Important Bird Area, based on A1-Globally threatened species, A2-Restricted-range species, and A3-Biome-restricted species criteria (BirdLife International 2016).

Despite its prominent conservation profile, CHNP contains one of the least understood avifaunal communities in Central America (Delgado 1985, Miller et al. 2015). Miller et al. (2015) combined data from five ornithological expeditions conducted in different regions of CHNP over the last three decades, resulting in the first bird species richness assessment ( $S = 225$ ), and the discovery of a potential new hummingbird species (Miller et al. in prep.). However, much of the higher elevations and isolated areas within the park remained unexplored, and some older records documented by Wetmore (1965, 1968, 1972), Wetmore et al. (1984), and Ridgely & Gwynne (1976, 1989) were not confirmed and not included in the checklist.

In 2016 and 2017, we conducted five ornithological expeditions aimed at exploring the highest elevation regions of CHNP. During these trips we identified nine species that had not been predicted to occur, four species of which are new local sightings (i.e., within Panama) and five represent range extensions (RE) from the previously recognized southern range limit. One of these RE include what we believe to be the Glow-throated hummingbird (*Selasphorus ardens*). However, definitive identification is difficult due to a scarcity of verified specimens in collections (Dyer & Vallely 2007). This finding suggests the existence of an isolated population of this rare and endangered species, separated by roughly 150 km of degraded lowlands from the northern population. We list a total of 26 bird species (Table S1, Supplementary Material online) that were not listed in the Miller et al. (2015) assessment checklist. A separate expedition by Cubilla & Groenendijk (2016) confirmed some of our findings along with one additional species which we did not find, the Rufous-crested Coquette (*Lophornis delattrei*). Our assessment also include species previously found only in historical records (i.e., that had not been sighted in over 50 years). Overall, our discoveries underscore the plethora of isolated populations among multiple taxa in CHNP. We briefly discuss the taxonomic status and biogeographical implications for five species of interest.

## METHODS

We explored three sites located in northern Cerro Hoya National Park mountains (Figure 1):

(1) Veraguas Province, Mariato: Pavo, El Águila (07°20'36"N, 80°40'30"W; 1213 m a.s.l.);

(2) Veraguas Province, Mariato: Pavo, Laberaldo (07°19'24"N, 80°44'W; 1490 m a.s.l.); and (3) Los Santos Province, Tonosí: La Bahía (07°20'24"N, 80°39'36"W; 1176 m a.s.l.).

Habitats at the three sites ranged between premontane wet forest and lower montane rainforest. Average annual temperature at these sites is 20°C, and annual rainfall (on peaks) is approximately 4000 mm (Holdridge 1964, ANAM 2014). Cattle pasture is the primary use of land in all neighboring lowlands.

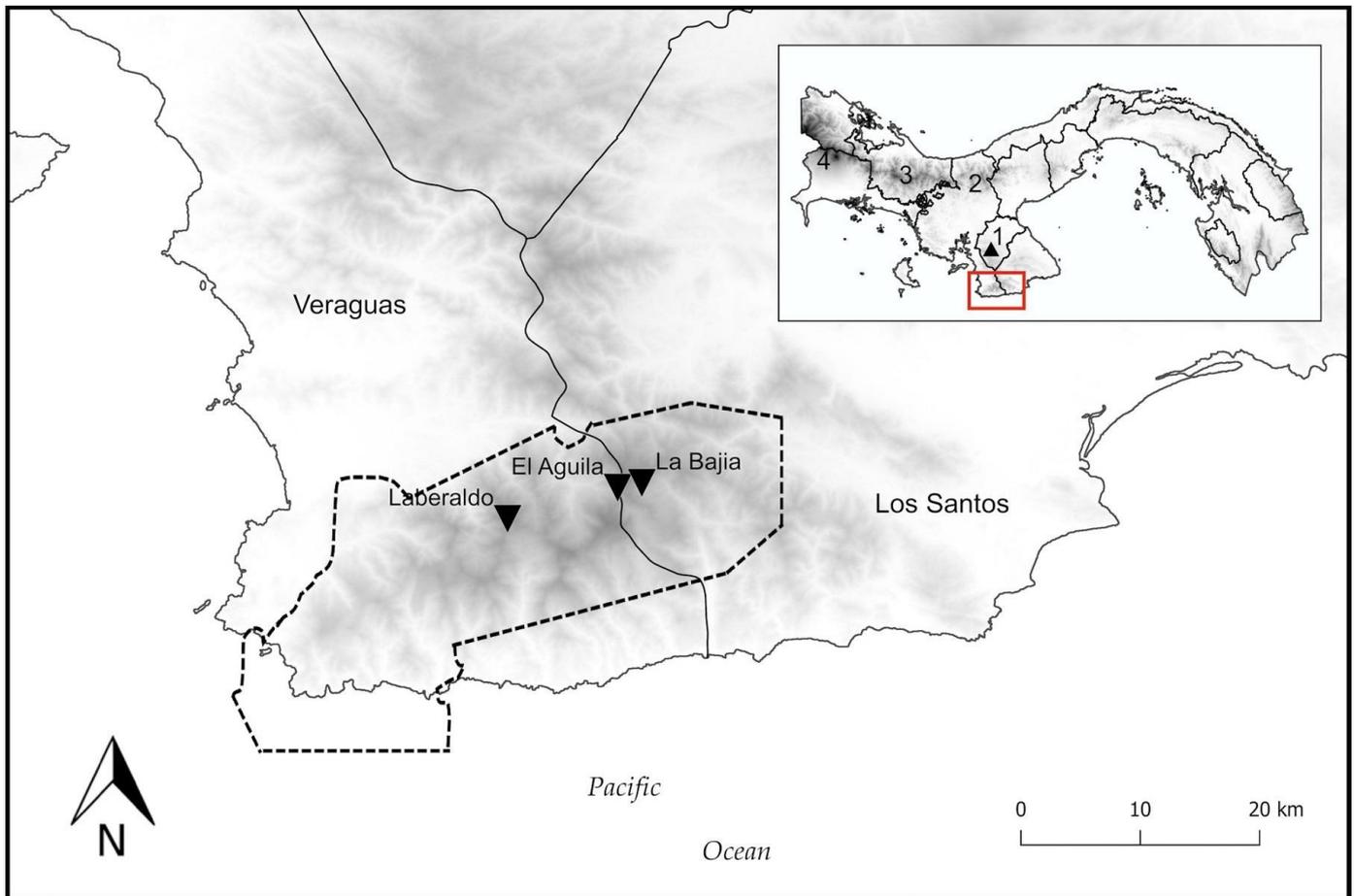
We visited each site twice, except for Laberaldo which we visited once, each time hiking through surrounding lowland pastures and ascending fragmented foothills. The trips were conducted between February and May 2016 and in February 2017 spanning the dry seasons and early rainy season. At El Águila, we established base camp at ~ 1170 m a.s.l., in Laberaldo at ~ 1250 m a.s.l., and at La Bahía in the foothills at ~ 850 m a.s.l. We conducted surveys of highland avifauna by mist-netting, recording vocalizations, and by direct observations (from base camps to > 1200 m a.s.l.). We also opportunistically photographed, recorded vocalizations, and made direct observations at all locations we trekked in the park. We used the Miller et al. (2015) checklist of birds to assess our expected avifauna since it represents the most comprehensive bird list of CHNP to date.

For some captured birds, we collected morphological measurements (mass, bill length, bill width, bill height, and wing, tail, and tarsus length) and blood samples for future genetic studies. Some of the captured birds were not previously reported and were collected and subsequently prepared as museum study skins by JLM, PLC, and JLG. Voucher specimens were deposited at the Smithsonian Tropical Research Institute Bird Collection (STRIBC) while genetic samples were deposited in the STRI BioBank (Table S1). All sampled specimens were processed according to specific protocols described in Winker (2000) and following the corresponding STRI IACUC protocol (2013-0801-2016-A1). We evaluated species sightings or captures as “range extensions” if the species 1) had not been verified in CHNP by any previous documentation at the time of the explorations, 2) was not predicted to occur in CHNP by either Ridgely et al. (2005) or Angehr & Dean (2010) field guide range maps, and 3) exceeded its previous southern range limit according to the *Handbook of the Birds of the World* (HBW, del Hoyo et al. 2014). Species with continuous ranges towards either South or North America were considered as new local ranges, and not range extensions.

We also reviewed species and subspecies identity, and examined morphological traits with reference to a variety of sources, such as Wetmore (1965, 1968, 1972), Stiles (1983), Wetmore et al. (1984), and Ridgely & Gwynne (1976, 1989) with the aim of determining taxonomy as confidently as possible. Scientific and English names, as well as species sequence, follow the AOU Checklist (Chesser et al. 2018) and supplements (Chesser et al. 2015, 2016). Specimens and samples were legally collected via scientific permits SE/A-118-15 and SE/A-105-16 provided by MiAmbiente (see Acknowledgments).

## RESULTS

In total, we recorded 178 bird species in 35 families and 17 orders during our expeditions. One additional species,



**Figure 1.** Localities visited during highland surveys (downward pointing triangles) in 2016 and 2017 in Cerro Hoya National Park, Panama. The black dotted line denotes the extension of Cerro Hoya National Park. In the smaller map, locations of El Montuoso Forest Reserve (1, upward pointing triangle), Central Cordillera (2), Serranía de Tabasará (3), and Talamanca Cordillera (4) are shown, as well as the location of CHNP (red square). Dark gray shadows indicate highland areas.

*Lophornis delattrei*, which we did not see, was photographed by J. Cubilla and K. Groenendijk (2016) during their expedition in April 2016 on the Veraguas side of the park. Five of these records represent the first recorded sightings south of the previously known species range and therefore are considered range extensions; four of these are commented in the species of interest section (also see Table S1). One of the latter, probably *Selasphorus ardens*, was previously suspected to exist in the park but previous rare sightings could not identify it to species level (Miller et al. 2015), hence being considered as hypothetical (Stiles & Sharpe 2018). In addition, four species, Black-and-white Hawk-Eagle (*Spizaetus melanoleucus*), Lesser Violet-ear (*Colibri cyanotus*), *Lophornis delattrei*, and Golden-olive Woodpecker (*Colaptes rubiginosus*) were also unexpected but their record(s) represent(s) a new locality (Figure 2, *L. delattrei* not shown), as they have a wider distribution to both the north and south of CHNP.

A total of 26 species are listed here (Supplementary Material online) and proposed as additions to the CHNP bird list (Table S1). These findings increase the known bird richness by 11.5%, to ca. 251 species. Of the 26 added records, 19 are non-passerines, 6 are montane obligate, and 4 are winter migrants. Three of the species were found in historical records but not included in the Miller et al. (2015) list: Barred Hawk (*Morphnarchus princeps*), collected in the early 20<sup>th</sup> century in Cerro Hoya, Sunbittern (*Eurypyga helias*), and Short-tailed Nighthawk (*Lurocalis semitorquatus*). Full

records of the expeditions are available on eBird by Buitrago et al. (2016) checklist S44441995 and Castillo et al. (2016) checklist S30986188.

**Species of interest.** Here we provide a brief review of our findings along with taxonomic and distribution status of five species (from three families) of interest.

#### TROCHILIDAE

##### **Lesser Violet-ear** (*Colibri cyanotus*, Bourcier 1843)

Two individuals of *C. cyanotus* were recorded. One was captured and photographed on 2 March 2016 (Figure 2b) while the second was collected on 10 February 2017. The collected specimen was sexed as a female by gonad dissection (ovaries: 1.7 x 1.0 mm, slightly granulated). Both individuals showed a slightly curved bill and had pinfeathers. Feathers on the neck, crown, and upper-back were bronzy-green with a slight iridescence. This coloration and the curved bill (Figure 2b) are typical and consistent traits with immature specimens of conspecifics from other mountain ranges deposited at STRIBC. While documenting only juveniles impedes a confident morphological comparison with museum specimens, it may indicate local breeding, and therefore potential reproductive isolation from conspecific populations.

*Colibri cyanotus* is an obligate montane species likely predicted to occur in CHNP according to the Angehr & Dean



**Figure 2.** Some remarkable species in Cerro Hoya National Park, Panama. a) Black-and-White Hawk-Eagle (*Spizaetus melanoleucos*), b) Lesser Violet-ear (*Colibri cyanotus*), c) Golden-Olive Woodpecker (*Colaptes rubiginosus*), d) Spot-Crowned Woodcreeper (*Lepidocolaptes affinis*), e) Mountain Thrush (*Turdus plebejus*), f) Flame-colored Tanager (*Piranga bidentata*). Photo credits: DBR, JLM, JO, and PLC.

(2010) range map. However, it was neither mentioned by Ridgely et al. (2005), nor recorded in eBird (Sullivan et al. 2009) or by del Hoyo et al. (2014). In addition, we could not find any previous account of the species in CHNP. However, a specimen was collected in Cerro Montuoso (within El Montuoso Forest Reserve) in 1977 by F. Delgado, who described it as “uncommon” (Ridgely & Gwynne 1989). Angehr & Dean (2010) correctly predict the occurrence of *C. thalassinus* (now *C. cyanotus*) in CHNP presumably based on Delgado’s record.

#### ***Selasphorus* sp.**

During our first trip to El Águila (3 March 2016), we collected three males (two adults and one immature, sexed by gonad dissection) of a small hummingbird showing an iridescent deep orange-red throat (depending on the angle of light incidence, Figure 3a right). A fourth specimen was captured, measured and sampled for genetic material, then released.

A similar-looking individual was collected in La Baja on 15 April 2016, but this specimen lacked the iridescent throat. During dissection, this individual was found to have ova consistent with that of a non-reproductive female. Differences between male and female plumage are shown in Figure 3.

Since the overall morphology of our specimens mostly resembles the small-bodied bee hummingbirds in western Panama (Angehr & Dean 2010), we referenced their morphology with that of members of the genera *Selasphorus* and *Calliphlox*, the only bee hummingbirds occurring in Panama (Table 1): Scintillant, Glow-throated, and Volcano Hummingbird (*Selasphorus scintilla*, *S. ardens*, and *S. flamula*, respectively), and Magenta-throated Woodstar (*Calliphlox bryantae*). Characters that have been used to distinguish these species include 1) male gorget color, 2) tail color pattern and rectrix shape (Wetmore 1968, Stiles 1983, Garrigues & Dean 2014), and 3) wing, tail, and bill lengths.



**Figure 3.** Male (a) and female (b) specimens of *Selasphorus* cf. *ardens* from Cerro Hoya National Park, Panama. Dorsal (left) and ventral (right) view of the collected specimens deposited at STRIBC. Due to the light incidence angles, the gorget of the male shows darker color and lack of iridescence than under frontal conditions.

Two of the male specimens present an iridescent deep orange-red gorget color, likely matching the gorget plumage of *Selasphorus ardens* as judged by images by Dyer & Vallely (2017); yet we were unable to compare specimens side by side. However, this color is noticeably different in *S. scintilla*, *S. flammula*, and *C. bryantae*. We next compared color patterns and rectrix shape of tail feathers with the CHNP specimens, referencing the descriptions by Stiles (1983). We found that the tail color pattern of our specimens resembles those of *S. ardens*. The males show a low degree of emargination on rectrix 1 (r1), which is typical of both *S. ardens* and *S. scintilla*. CHNP male specimens have darker rectrices than *S. scintilla* matching the phenotype of previously collected *S. ardens* (Stiles 1983). The tail of the female also matches Stiles' description showing a low degree of emargination in all rectrices (Figure 3b) and a wide green stripe in r1. However, the lack of verifiable specimens (Dale & Vallely 2017) for this species impedes discrimination based on this trait.

We also compared culmen length, wing chord, and tail length (Table 1) using data compiled from STRIBC, Wetmore (1968), and eight adult male specimens identified as *S. ardens* by Dale & Vallely (2017). CHNP male specimens have larger culmen length values on average than males of other congeners. In contrast, wing chord and tail length average values are larger than that of *S. scintilla*, but smaller than that of *S. ardens* and *S. flammula* (Table 1). Female measurements are most similar to that of Wetmore (1968) for *S. ardens* (not included in Table 1), but again this comparison must be made with caution (Dyer & Vallely 2017). Culmen length, wing chord, and tail length of the CHNP female speci-

men fall also within the range of female of *S. scintilla* and *S. flammula*, respectively (Table 1).

Given the complexity of the topic, we provide further review of morphological traits, taxonomy, and species distribution in CHNP in the discussion section.

#### FURNARIIDAE

##### **Spot-crowned Woodcreeper** (*Lepidocolaptes affinis*, Lafresnaye 1839)

DBR and JLM photographed two individuals of this species, one at La Bajía mountain on 15 March 2016 at 1200 m a.s.l. and the other on 10 February 2017 at 1450 m a.s.l. (Figure 3d). The species was identified by the combination of a slightly decurved pale bill and small spots on the crown. The previous southernmost distribution of this species refers to the subspecies *L. affinis neglectus* ranging from Costa Rica highlands to western Panama. There are no records of this species from the highland zones of Central Panama. According to eBird (Sullivan et al. 2009), the nearest previous records are from Cerro Santiago in the western end of the Serranía de Tabasará (Comarca Ngabe-Bugle) 179 km (linearly) from El Águila.

#### TURDIDAE

##### **Mountain Thrush** (*Turdus plebejus*, Cabanis 1861)

JO photographed one individual of this species at approximately 1430 m a.s.l. near the summit of a peak adjacent to La Bajía mountain on 12 May 2016 (Figure 2e). Other individuals were photographed on 10 February 2017 by JLM. The

**Table 1.** Morphometric traits of bee hummingbirds from western Panama and the Cerro Hoya individuals (*Selasphorus cf. ardens*). Values are min–max (mean) in mm, n = samples (males; females). Super index letters after species name indicate data sources: <sup>a</sup>STRIBC (measured by JLM), <sup>b</sup>Wetmore (1968), and <sup>c</sup>AMNH (Dyer & Vallely 2017).

Species	Culmen length		Wing chord		Tail length	
	Males	Females	Males	Females	Males	Females
<i>Calliphlox bryantae</i> <sup>a</sup> n = 5 (2; 3)	14–15.2 (14.7)	16.2–17 (16.6)	41.9–42.8 (42.2)	41.9–44.4 (43.5)	33.8–35.4 (34.8)	21.8–24 (22.8)
<i>Selasphorus flammula</i> <sup>b</sup> n = 5 (4;1)	10.4–11.1 (10.8)	13.2	40.2–41 (40.7)	44.7	27–28.7 (28.1)	27.2
<i>Selasphorus scintilla</i> <sup>a</sup> n = 6 (3;3)	9.7–11.1 (10.5)	11.5–12.5 (11.9)	32–36 (33.5)	35.3–37.9 (36.7)	23.8–24.1 (24.3)	24–24.8 (24.4)
<i>Selasphorus ardens</i> <sup>c</sup> n = 8	10.3–12 (11.4)		39.4–40.4 (40.2)		28–33 (30.5)	
<i>Selasphorus cf. ardens</i> <sup>a</sup> n = 5 (4;1)	10.4–14.1 (12.1)	12.5	36.1–41.3 (38.6)	39.5	25.2–29.7 (27.5)	25.5

previous distribution of this species was limited to the Talamanca mountain range and the western end of the Tabasará mountain range. There are no records of this species from Central Panama. According to eBird (Sullivan et al. 2009), the nearest previous records are from Cerro Santiago, in the Tabasará mountain range.

#### CARDINALIDAE

##### Flame-colored Tanager (*Piranga bidentata*, Swainson 1827)

PLC saw an individual of *Piranga bidentata* near the summit of El Águila on 4 March 2016. DBR confirmed this finding when a pre-adult male appeared in a photograph of a mixed flock in the same area on 3 April 2016. Additionally, two males were seen by DBR on April in La Bajía. Females of this species were sighted on 21 and 22 April 2016 in the same region by Cubilla & Groenendijk (2016). The white wing bars, white tip of the tail and the orange coloration were indicative for identification (Figure 2f). The southern Central American subspecies of the Flame-colored Tanager, *P. bidentata citrea*, is restricted to the Talamanca mountain range (Wetmore et al. 1984) and it represents the closest population of this species to CHNP. We found no evidence of records in other mountain ranges.

#### DISCUSSION

**Cerro Hoya is a sky-island of avifaunal diversity.** The results of our upland expeditions highlight Cerro Hoya as a sanctuary of avifaunistic diversity in the Mesoamerican isthmus in at least two ways. First, the park harbors potential genetically isolated populations of highland and forest-restricted bird species. CHNP is surrounded by either coastal lowlands or large swaths of deforested and human-inhabited plains making it geographically separated from other mountain systems in Mesoamerica. While gene flow between other highlands is possible, it is likely infrequent given the large distance to the closest populations and harsh habitat spanning the interconnecting lands. Therefore, some isolated populations may be genetically dissimilar or even different at species level from conspecifics (e.g., Manthey & Moyle 2015). This has been proposed for a phenotypically unique *Lampornis* hummingbird in the park (Miller et al. 2015) and might also apply to *Colibri cyanotus*. A taxonomic revision of

the Green Violet-ear (*C. thalassinus*) complex resulted in a new classification of lower Mesoamerican populations as *C. cyanotus* (Remsen et al. 2015). Therefore, we urge further phylogenetic studies incorporating samples from these isolated populations. Moreover, future expeditions should explore divergence in morphological and behavioral traits, all of which have been shown to reveal cryptic variation in this group (Barrantes et al. 2008, Lara et al. 2015, Hernández-Soto et al. 2018, Quintero & Perktas 2018).

Second, difficult access to highlands of CHNP has slowed human encroachment leaving an intact forested habitat larger than anywhere else on the Azuero Peninsula. Birds typically found in lowland forests may have been gradually forced toward higher altitudes simply because lowlands are continuously converted to pastures (Wright & Samaniego 2008). For instance, Cocoa Woodcreepers (*Xiphorhynchus susurrans*) and Long-billed Hermits (*Phaethornis longirostris*) are both more common in lowlands up to 600 m a.s.l. (Angehr & Dean 2010). In CHNP, we found both species above 1200 m a.s.l. While decreased competition with other species is a potential explanation to this shift, it is important to consider that lowland birds in CHNP may colonize higher elevations as a response to disturbances in their habitats. This type of shift has been observed (due to climate change) in other Neotropical regions with similar altitudinal ranges (Freeman et al. 2018).

**Range extensions.** During our expeditions, we sighted or captured nine species which were not expected in the region. We considered five of these to be RE and are particularly important because they not only provide species range novelties but also valuable information for further biogeographical and phylogenetic studies of highland taxa. For example, the sightings of *Lepidocolaptes affinis*, *Turdus plebejus*, and *Piranga bidentata* are the most southern records throughout their ranges. Therefore, we propose to include CHNP as the limit of their distribution (unless a future taxonomic study will rearrange current classification and species ranges). These isolated populations may have resulted from dispersal events across lowlands during the Pleistocene (Piperno et al. 1990, Leyden et al. 1993). Alternatively, species apparently resident in El Montuoso Reserve (e.g., *Colibri cyanotus*) may have crossed along corridors of middle-elevation forests between CHNP and El Montuoso

multiple times. Another hypothesis concerning recent distribution traits is human-assisted dispersion. For example, the Crimson-fronted Parakeet (*Psittacara finschi*), listed here as a RE, is frequently kept in captivity and was observed as a pet in local communities. It is possible that this species may have been accidentally introduced to the region through the pet trade.

**Species identity and distribution of *Selasphorus* sp.** The identification of the bee hummingbird in CHNP merits special attention given its former ambiguity (Stiles & Sharpe 2018), the notorious similarity in appearance of many species in this clade, and implications for endemic Panamanian avifauna. Southern Central American bee clade hummingbirds (McGuire et al. 2014) encompass three species of resident birds forming the *Selasphorus* complex (*S. flammula*, *S. scintilla*, and *S. ardens*), and *Calliphlox bryantae* and *C. mitchellii*. All range from Costa Rican Central and Talamanca mountain ranges to Serranía de Tabasará in Panama (except *C. mitchellii*). Though a small and isolated population of the Purple-throated Woodstar (*C. mitchellii*) exists in easternmost Panama, we excluded it from this analysis due to a lack of specimens from the Panamanian populations and an unambiguous distinction from the CHNP bee specimens (Robbins et al. 1985).

Using the dichotomous key in Wetmore (1968), we preliminarily identified the CHNP specimens as *Selasphorus ardens* by combining tail length and elongation of the margin of the iridescent gorget. However, since Wetmore's key was published, several changes have been made to the identification of this group of hummingbirds (Stiles 1983, Dyer & Vallely 2017). Additionally, numerous misidentifications and labeling errors of the already rare specimens have only recently been addressed, and no specimen of *S. ardens* has been collected since 1924 (Dyer & Vallely 2017). Therefore, with the limited but most up-to-date resources available, we compared the CHNP specimens in detail to related species of the region.

Similar to the few *Selasphorus ardens* present in collections, CHNP male specimens show an iridescent deep orange-red colored and concave shaped gorget. However, the gorget is a weak identification feature as the same color and shape have evolved independently in other taxa of the complex, for example in *S. flammula simoni* (Stiles 1983).

*Calliphlox bryantae* shows a marked sexual dimorphism in tail shape and length, which was not found in the CHNP specimens. We therefore excluded this possibility. Within the genus *Selasphorus*, though value ranges of some of the morphological measurements (culmen, wing, and tail lengths) overlapped between CHNP specimens (*Selasphorus* sp.) and *S. flammula* and *S. scintilla*, all traits overlapped with those of *S. ardens*, suggesting an affinity to this species. Comparison of tail color pattern and shape also demonstrated a close resemblance to *S. ardens*. Thus, in general our comparisons most likely support an identity of the CHNP specimens as *S. ardens* yet are not conclusive. Dyer & Vallely's (2017) attempt to verify the identity of the *S. ardens* females described in Wetmore (1968) and Stiles (1983) found that these descriptions cannot be reconciled with each other, and that no putative female specimen of *S. ardens* contains unambiguous labeling. Therefore, no indisputable female *S. ardens* from the previously

known range can be compared to the CHNP female specimens.

The occurrence of a bee clade hummingbird in CHNP had not been confirmed until now. Initially, an apparently *S. ardens* individual was collected by F. Delgado in 1994, but was lost without description or photo, making verification impossible (Miller et al. 2015). Later, an individual resembling a bee hummingbird was photographed by L. Martinez, but identification was difficult without closer detail (Miller et al. 2015). Lastly, expeditions in 2011 and 2013 failed to detect any bee hummingbird species. Consequently, Miller et al. (2015) proposed to exclude the genus *Selasphorus* from the CHNP avifauna list until a formal collection and species verification was made.

Here we confirm an isolated population and therefore RE of a bee hummingbird in the genus *Selasphorus* in CHNP, and a RE for the entire genus. Based on the combination of gorget and tail morphology, and overlap with the phenotypical characters of known *S. ardens* specimens, we suggest a preliminary classification of the CHNP specimens as *Selasphorus* cf. *ardens*. We provisionally use the qualifier "cf." to indicate that most of the diagnostic characteristics correspond to the proposed species though others remain unclear (Sigovini et al. 2016). Further taxonomic assessment for *S. cf. ardens* will require morphological and genetic analysis with the type specimen population. However, this is currently not possible given that specimens of *S. ardens* have not been collected for nearly a century, and there is a lack of verified female specimens (Dale & Vallely 2017). Nonetheless, the rarity of this species and its endangered status merit urgency to further study.

**Conservation.** Pristine highland environments of CHNP are threatened by a combination of natural and human-mediated factors. Since high temperatures may promote altitudinal shifts in species distribution (Freeman et al. 2018), CHNP could be sensitive to diversity loss given that montane restricted species are likely "trapped" unless they are capable of colonizing other distant highlands (Warshall 1995, Şekercioğlu et al. 2012). Deforestation degraded 10% of the protected area of CHNP by 2000 (Angehr 2003), and to date deforestation in the highlands is strikingly rapid. In 2011 and 2013, the STRIBC team visited forested areas from 700–800 m a.s.l. on both sides of the park. However, in 2016 we witnessed burns in these same areas over 800 m a.s.l. in Pavo and as high as 1000 m a.s.l. near La Bajía. Thus, climate change combined with habitat loss and recurring climatic breaks (e.g., El Niño) make the scenario for local highland wildlife grim. It will be informative to evaluate the effects of all these threats on ecological and evolutionary interactions in the avian community.

Fortunately, the plethora of fascinating and rare taxa should be helpful in raising conservation (Flesch et al. 2016) and ecotourism interest in the park. For example, all three species of Hawk-Eagles (genus *Spizaetus*) are confirmed here and in Miller et al. (2015) to occur in the area. The genus makes up the largest birds of prey in Panama except for Harpy Eagle (*Harpia harpyja*) and Crested Eagle (*Morphnus guianensis*), both apparently absent in CHNP. Hummingbirds are also widely cherished, and the park now boasts the presence of at least one new species (Miller et al. in prep.) and the rare Panamanian endemic *Selasphorus* cf. *ardens* (this

study). Their presence and potential endemism in CHNP merits special attention since ranges are limited to a small region in southern Azuero Peninsula and population status remain uncertain. If the latter is further confirmed as *Selasphorus ardens*, its conservation status will make CHNP home to four IUCN threatened bird species, which may intensify protection efforts in the park. A model of ecotourism including endemic birds, local guiding, and cultural exploration has proven successful for both conservation and sustainable human development (Martínez Mauri et al. 2014). We advocate a similar strategy here as the fate of protected areas will largely depend on future actions of local people (Wright & Samaniego 2008).

## ACKNOWLEDGMENTS

Research funds and scientific permits were provided by the Neotropical Bird Club and the Panamanian environmental authority (MiAmbiente). IDEA WILD provided field equipment and materials. We are grateful to E. E. Flores, D. Rivas, V. De Gracia, and B. Peña, who provided logistical support. We are thankful to N. E. Jaén, who provided help, advice, and valuable observations during the field trips. Dale Dyer provided expert opinion on *Selasphorus* identification. In addition, we thank the local guides L. Rivera, J. Rivera, and B. Díaz for bringing local knowledge to the project. M. J. Miller, M. M. Dixon, D. L. Falk, and D. Dyer provided improvements to this manuscript. Data provided by NatureServe in collaboration with R. Ridgely, J. Zook, The Nature Conservancy - Migratory Bird Program, Conservation International - CABS, World Wildlife Fund - U.S., and Environment Canada - WILDSpace. This work was supported by the STRI Biological Collections for Scientific Research. This is STRI Bird Collection Publication no. 17.

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