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Range extension to Santo Domingo de los Tsáchilas province and revised distribution of *Platyrrhinus chocoensis* (Phyllostomidae: Chiroptera) in western Ecuador

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Abstract. We report the first record of the Choco broad-nosed bat (*Plathyrrhinus chocoensis* Alberico & Velazco, 1991) in Santo Domingo de los Tsáchilas province in northwestern Ecuador. This voucher specimen represents the southernmost record of the species and expands its distribution *ca.* 120 km south. The animal was caught at a farm, specifically in a live fence consisting of several tree species. Preservation of bat species occurring in agricultural landscapes requires local policies and environmental education.

Key-Words. Mammalia; Bats; Biogeography; New record; Ecuador.

INTRODUCTION

Located in the northwestern Pacific coast of South America, the Tumbes-Chocó-Magdalena bioregion is one of 25 world hotspots due to its high biodiversity (Mittermeier *et al.,* 1999; Myers *et al.,* 2000). This bioregion includes the Chocó-Darien moist forests (Chocó) located on the Pacific coast of northwestern Ecuador (Myers *et al.,* 2000). Ecuador, despite its small area, displays high mammalian diversity, with 424 species (Tirira, 2016). The order Chiroptera is the most numerous (Tirira, 2007; Albuja, 2011), with 171 species (Tirira, 2016) found in all zoogeographical zones in Ecuador (Albuja, *et al.,* 2012). More specifically, the northwestern forests house at least 85 species (Tirira, 2008; Burneo & Tirira, 2014), of which at least 20 have been recorded in agricultural landscapes (Pozo-Rivera & Eras, 2012; Pozo-Rivera, 2013; Pozo-Rivera *et al.* 2015).

Ecuador Choco extends from the province of Esmeraldas to the Pasado cape in the province of Manabí (Boada, 2006). On the eastern side, it includes the lowlands of Carchi, Imbabura, Pichincha (Botero-Chica, 2010), and Santo Domingo de los Tsáchilas to reach the Troncal locality in the province of Guayas. Ecuadorian Choco contains 9,000 species of vascular plants, 120 amphibians, 100 reptilians, 600 avians (Botero-Chica, 2010), and 167 mammals (Tirira, 2008; Jarrín-V & Kunz, 2011; Moratelli & Wilson, 2011). It is estimated that only 12.5% of pre-European contact, western Ecuadorian forests are conserved (Sierra *et al.,* 2002; Boada, 2006). Causes of forest loss include expansion of agriculture, logging, population growth (Huttel, 1999), mining (Paredes, 2010), and tourism (Cueva-Arroyo *et al.,* 2013). Although several private and state protected areas (MAE, 2015) have been established in the zone, monocultural agrosystems (Huttel, 1999) threaten the local ecology (Zuppinger-Dingley *et al.,* 2015).

The broad-nosed bats of the genus *Platyrrhinus* (subfamily Stenodermatinae, family Phyllostomidae) live in tropical lowland and montane forests up to 2,550 m asl (Velazco & Gardner, 2009), from Mexico to northern Argentina (Gardner, 2007). Most species are essentially frugivorous but occasionally feed on insects, nectar,

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and pollen (Albuja, 1999) by gleaning in narrow forest areas (Kalko *et al.,* 2008). The genus *Platyrrhinus* is morphologically distinguished by a fringe of hair on the edge of uropatagium, molars 3/3, and two accessory cusps on M2 (Tello & Velazco, 2003; Lim, 1993). *Platyrrhinus* currently contains 21 species (Simmons, 2005; Velazco & Gardner, 2009; Velazco *et al.,* 2010; Velazco & Lim, 2014), of which 13 inhabit Ecuador (Albuja, 2011). Among these, *P. chocoensis, P. dorsalis, P. helleri, P. lineatus, P. nitelinea,* and *P. matapalensis* have been recorded in western Ecuador (Albuja, 2011).

The Choco broad-nosed bat *Platyrrhinus chocoensis* (Alberico & Velazco, 1991) occurs in the lowlands of the Colombian and Ecuadorian Choco region, at elevations between 35 and 1,000 m. In Ecuador, the species is known from 29 localities (Appendix 1), with its southernmost record in Sade, Esmeraldas Province (00°31'04.0"N, 79°20'28.9"W) (Gardner, 2007; Ramirez-Chaves & Suárez-Castro, 2015; Loaiza-S, unpublished data). The species is classified as Vulnerable A2c, because the population decline is probably closer to over 30% and habitat loss (Ramirez-Chaves & Suárez-Castro, 2015), but in Ecuador it is considered an endangered species (Burneo *et al.,* 2015). Morphologically, *Platyrrhinus chocoensis* possesses buff facial stripes (no shine) (Albuja, 1999), a buff and undulated dorsal stripe, bicolored ventral fur (Gardner, 2007), genal vibrissae lacking a basal protuberance directly over the cheeks [a character evident only in specimens preserved in alcohol (Velazco, 2005)], one vibrissae on each side of the upper lip away from the baseline to seven vibrissae surrounding the noseleaf, one interramal vibrissae (Velazco, 2005), an inverted U-shaped posterior margin of the uropatagium, and the absence of a stylar cuspule on the lingual face of the M2 metacone (Gardner, 2007; Velazco & Gardner, 2009).

This communication reports on the first record of *Platyrrhinus chocoensis* for the province of Santo Domingo de los Tsáchilas, northwestern Ecuador and proposes a new geographical distribution for the species.

MATERIAL AND METHODS

We collected bats using mist nets in an agricultural landscape in western Ecuador from September, 2012 to March, 2015. Most were identified *in situ,* but those that were difficult to identify were sacrificed following guidelines of the American Society of Mammalogists for the use of wild mammals in research (Sikes *et al.,* 2011) and the specifications outlined in the Authorization of Scientific Research № 10-2013-IC-FAU-DPAP-MA granted by the Ministry of Environment of Ecuador. Voucher specimens were deposited at the Museo de Investigaciones Zoológicas del IASA, Universidad de las Fuerzas Armadas (MIZI). We identified specimens at the genus level following Jones & Carter (1976), Albuja (1999) and Tirira (2007), and used Gardner (2007) and Velazco & Gardner (2009) for species identification.

For comparative purposes, we also examined 31 specimens of *P. chocoensis* deposited in the Museo Ecuatoriano de Ciencias Naturales (MECN), Museo de Zoología de la Pontificia Universidad Católica de Quito (QCAZ), Instituto de Ciencias Biológicas de la Escuela Politécnica Nacional (MEPN), Museum of Texas Tech University (TTU), and Museo de Investigaciones Zoológicas (MIZI) (Appendix 1). Additionally, we measured 17 cranial variables following Velazco & Gardner (2009). We calculated descriptive statistics of cranial and postcranial measurements using InfoEstat® (Balzarini *et al.,* 2013). We modeled the species habitat and potential distribution using Maximum Entropy Modeling (Maxent) (Phillips *et al.,* 2006), and we calculated home range based on historical records of the species in Ecuador using Minimum Convex Polygon (MCP). Environmental variables were downloaded from www.worldclim.org (Hijmans *et al.,* 2005) in format ESRI grind ca 1 km. To increase modeling accuracy, we performed 10 replicates, 500 interactions, and 10,000 background points.

RESULTS

On February 8, 2012, RAB and WEPR collected-in a life fence at San Antonio Farm (Ecuador) a bat specimen initially identified as *Vampyrodes caraccioli* based on the presence of two central, markedly convergent incisors (Pozo-Rivera, 2013). The specimen was deposited under museum number MIZI 2012397. However, during a recent curation of the mammal collection in MIZI, WEPR and KYA found errors with the identification of the voucher and reassigned it to *Platyrrhinus chocoensis* (Fig. 1) based on Gardner (2007) and Velazco & Gardner (2009).

The specimen of *Platyrrhinus chocoensis* was collected at the San Antonio Farm, located close to the boundary of the Los Rios and Santo Domingo de los Tsáchilas provinces (00°31'32.0"S, 79°19'21.3"W), at an elevation of 327 m asl (Fig. 2), and was identified as an adult male. The animal was caught by mist nets placed over a biodiverse life fence composed of several plant species (*Erythrina smithiana, Citrus* spp., *Coffea arabiga, Jatropa curcas,* and others). Other bat species collected at the same farm were *Artibeus aequatorialis, Carollia brevicauda, C. perspicillata, Chiroderma villosum, Glossophaga soricina, Myotis riparius, Sturnira lilium,* and *Vampyriscus nymphaea* (Pozo-Rivera, 2017). This record extends the range distribution of *Platyrrhinus chocoensis ca.* 120 km south, away from its currently recognized distribution area (Gardner, 2007; Ramirez-Chaves & Suárez-Castro, 2015).

The predictive model using Maxent, based on 31 specimens with accurate collection sites, is shown in Fig. 2; the area under curve (AUC) value of receiver operating characteristic curve (ROC) was 0.987. Based on these reports, the home range of the species, calculated by minimum convex polygon, reaches 14,904.7 km^2 (Fig. 2). Environmental variables which most influenced the distribution modeling were minimum temperature of coldest month (69%), and temperature annual range (8.1%).

The cranial and postcranial measurements of the specimen fell within the range of the Colombian (Velazco & Gardner, 2009) and Ecuadorian specimens

Figure 1. Frontal (A) and lateral (B) views of a live specimen of *Platyrrhinus chocoensis* collected by WEPR and RAB in San Antonio Farm (voucher number MIZI2012397).

(Table 1). Based on the *P. chocoensis* vouchers deposited in MECN, QCAZ, TTU, and on our record, we propose that the new species distribution extends to Santo Domingo de los Tsáchilas province (Fig. 2). Furthermore, according to Burneo & Tirira (2014), it may extend to the Los Rios Province and may reach the lowland moist forests of the Los Guayas Province, considering the similar ecological characteristics of these forests.

DISCUSSION

Vertebrate and invertebrate distribution extension records are not uncommon across the Americas and are mainly based on studies of Natural Reserve Areas (Pereira, 2010; Gregory *et al.,* 2015; Pachelle *et al.,* 2015; Medina *et al.,* 2016; Sikes & Allen, 2016). This is also the case in Ecuador, where most field studies on Chiroptera were conducted in areas belonging to the National System of Protected Areas (Baker *et al.,* 2009; Loaiza-S, 2010; Moratelli & Wilson, 2011). This leaves agricultural areas, and agrosystems in general, open to scrutinized fieldwork with potentially interesting findings on bat distribution. In effect, absence of bat distributional data in areas affected by human activities may be mainly due to lack of monitoring effort, considering their floristic and climatic similarities to non-anthropogenically impacted areas. It is thus very likely to expect distribution extension records of bats in such areas, as with the present report. The Ecuadorian Rain Forests belonging to the Choco-Darien ecoregion were originally settled in the Esmeraldas, Manabí, Santo Domingo de los Tsáchilas, Los Rios, Western Pichincha and Eastern Guayas Provinces (CEPF, 2005), so a record of endemic Chocoan species was to be expected in any locality of these provinces. In fact, Burneo & Tirira (2014) predicted the potential southern extent in the distribution of *P. chocoensis* before the present report.

Ramirez-Chaves & Suarez-Castro (2015) report that *P. chocoensis* occurs in the lowlands of southern Panama and the Pacific region of Colombia, south to northwestern Ecuador. However, according to our observations on specimens deposited in museums made before this report, *P. chocoensis* in Ecuador occurred only in the Esmeraldas province.

Considering the ecological similarities across ecosystems (Drechsler *et al.,* 2007), many mammals demonstrate very wide distribution ranges, such as the recent record of *Coendu istichillus* (Voss & da Silva, 2001) at 900 km away from the known boundaries of its previously recognized distribution area (Gregory *et al.,* 2015). In fact, the scientific literature argues that the majority of range extension records are due to lack of monitoring effort (Rocha *et al.,* 2013; Salas *et al.,* 2013, Novaes *et al.,* 2014). On the other hand, one should also consider that landscape and ecosystem anthropogenic modifications may further contribute to range extension. The present record of *P. chocoensis* was noted in an altered zone occupied by agricultural landscape, and this may indicate that some species are in the process of adapting to en-

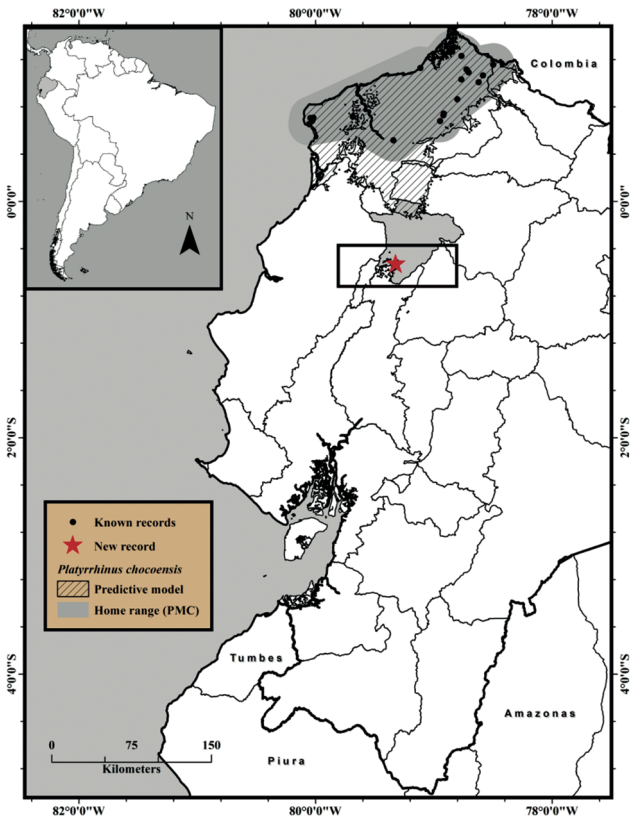

Figure 2. Predictive habitat model using Maxent (AUC value = 0.987), based on 31 specimens with accurate collection sites (black circles) and the new record of *Platyrrhinus chocoensis*. The shadow under the predictive model corresponds to home range extension before our record. The star represents the new southernmost record reported in this communication.

vironmental changes (Darwin, 1869; Hansen *et al.,* 2001; Schmidt & Jensen, 2003).

Northwestern Ecuadorian ecosystems have been greatly changed by agriculture (Maestri & Paterson, 2016). The finding of vulnerable species such as *P. chocoensis* in these areas places a great responsibility on conservationists and environmental scientists and educators. Joint actions are necessary to effectively conserve mammal species in agricultural landscapes. A special concern involves educating local stakeholders on the important ecological role of bats, especially the species directly linked to agricultural production, as landholders and farmworkers believe that bats are harmful, extracting blood from cattle or destroying fruit plantations. This results in an intentional and significant decline in bat populations around farms, rendering their protection and conservation in agrosystems a difficult but crucial task, requiring local policies to undertake appropriate bat conservation programs.

Several farms implement life fences, dispersed tree cover pastures, forest fragments, and riparian forest to promote wildlife conservation on agroecosystems (Vilchez-Mendoza *et al.,* 2014). These ecological production alternatives do not guarantee the survival of the species on farms, however. Many bats are killed by smoke from fires set by landholders who are unaware of the ecological importance of bats for pest control, pollination, and seed dispersal.

Table 1. Comparative cranial and postcranial measurements of *P. chocoensis* from San Antonio farm in Santo Domingo de los Tsáchilas Province (MIZI2012397), from published work by Velazco & Gardner (2009), and from specimens deposited in mammalian collections in Ecuador [mean ± SD, range (number of specimens)]. Measurement acronyms are explained in Appendix 2.

Postcranial* and cranial measurements	MIZI2012397	Velazco & Gardner (2009)	Ecuadorian Museums
HB*	73	—	72.72 ± 3.37 67-80 (20)
F*	20.5	—	18.84 ± 1.53 14.28-21.00 (20)
E*	15.51	—	13.77 ± 1.71 11.00-17.00 (20)
FA*	51.46	48.8 ± 1.20 46.9-50.7 (19)	49.41 ± 2.93 39.69-53.00 (20)
W*	28	—	29.97 ± 4.71 18.00-35.00 (15)
GLS	28.14	27.6 ± 0.64 26.5-29.0 (21)	28.45 ± 0.85 25.35-29.15 (18)
CCL	24.76	24.8 ± 0.66 23.6-25.9 (21)	25.07 ± 0.82 22.24-26.15 (18)
CIL	25.6	25.2 ± 0.67 24.3-26.6 (21)	25.77 ± 0.89 22.68-27.35 (18)
BB	11.36	11.8 ± 0.19 11.3-12.2 (21)	11.86 ± 0.38 10.67-12.34 (18)
ZB	16.84	16.5 ± 0.43 15.6-17.2 (21)	16.69 ± 0.83 13.88-17.56 (18)
PB	6.28	6.4 ± 0.21 6.0-6.8 (21)	6.51 ± 0.23 6.03-6.83 (18)
MB	12.51	12.6 ± 0.19 12.2-12.9 (21)	12.82 ± 0.45 11.14-13.23 (18)
PL	14.45	14.1 ± 0.45 13.2-15.0 (21)	14.46 ± 0.56 12.51-15.21 (18)
MLTRL	8.45	—	8.66 ± 0.31 7.82-9.26 (18)
MTRL	11.04	10.7 ± 0.32 10.1-11.3 (21)	10.67 ± 0.41 9.28-11.20 (18)
M1-M1	10.61	11.0 ± 0.36 10.2-11.6 (21)	11.35 ± 0.38 10.56-12.16 (18)
M2-M2	11.52	11.5 ± 0.32 10.7-12.1 (21)	11.72 ± 0.36 10.72-12.35 (18)
MXBR	6.1	—	6.72 ± 0.23 6.26-7.18 (18)
C-C	7.34	—	7.5 ± 0.42 6.04-7.95 (18)
DENL	19.56	19.6 ± 0.54 18.8-20.5 (21)	19.95 ± 0.78 17.22-20.96 (18)
MANDL	11.86	11.6 ± 0.31 11.0-12.1 (21)	12.36 ± 0.26 11.78-12.85 (17)
COH	7.07	—	7.05 ± 0.37 5.91-7.60 (18)

CONCLUSIONS

The distribution of *Platyrrhinus chocoensis* extends to the province of Santo Domingo de los Tsáchilas, Ecuador. Furthermore, taking into account similarities between ecosystems, the species may also inhabit rain forests or agroecological farms of Los Rios Province up to the western rain forests of Los Guayas Province. Considering its Vulnerable status, developing conservation measures such as environmental education campaigns is crucial to raise awareness of the importance of bats for crops in agricultural areas to guarantee the continuality of this range.

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APPENDIX 1

Examined specimens deposited in Ecuadorian museum

Museum acronyms are found in the methodology section, localities are present as follow:

PROVINCE (Number of specimens)
County:
Parish,
Locality, Latitude, Longitude: MUSEUM NUMBER (F = female, M = male, U = Unknown sex).

CARCHI (5)
Tulcán:
Tobar Donoso,
Vía Lita Bosque Maduro, 01°09'27.0"N, 78°29'50.3"W: MECN2884 (F), MECN2872 (M), MECN3263 (M), MECN2913 (F), MECN without voucher number (U).

ESMERALDAS (43)
Eloy Alfaro:
La tola,
Molina stream, 2 km south Mataje, 01°07'45.6"N, 79°06'46.4"W: MEPN004320 (U), MEPN004323 (M).
Luis Vargas Torres,
2 km south Playa de Oro; 00°51'56.7"N, 78°48'04.6"W: MEPN3177 (F), MEPN3178 (F), MEPN1923 (F), MEPN001924 (U), MEPN6678 (M).
Telembi,
3 km south San Miguel town; 00°43'00"N, 78°55'08"W: MEPN3013 (F), MEPN3072 (F), MEPN3075 (F).
Poblado San Miguel; 00°43'47.8"N, 78°55'08.9"W: MEPN003263 (F).
Salto del Rio Bravo; 00°40'53.4"N, 78°56'46.1"W: MEPN9133 (F), MEPN9134 (M), MEPN2110 (M), MEPN2121 (F).
Muisne:
San Francisco,
Chipa stream; 00°42'26.0"N, 80°02' 33.7"W: MECN3073 (M).
El Aguacate stream; 00°39'12.5"N, 80°03'06.8"W: MECN2081 (M).
Inés stream; 00°40'54.7"N, 80°01'39.6"W: MECN3064 (M).
Partidero stream, Poza Honda; 00°42'32.8"N, 80°01'01.7"W: MECN3109 (F).
Quinindé:
Malimpia,
Sade Town, 8 km east of Sade river; 00°31'04.0"N, 79°20'28.9"W: MEPN3361 (U), MEPN003362 (F), MEPN3398 (5 specimens: 3F, 1M, 1U).
San Lorenzo:
San Lorenzo,
Crnl. Carlos Torres, Taquiama stream, right side Rio Tiaone, 00°43'N, 79°41'W: MEPN3459 (M).
Choco, San Lorenzo, 01°16'10.6"N, 78°50'38.1"W: QCAZ9208 (F).
Estación Experimental "La chiquita", 12 km south San Lorenzo, 01°13'55.2"N, 78°45'57.7"W: MEPN002120 (F), TTU85426 (F), TTU???? (F).
Santa Rita,
San Francisco de Bogotá, 14 km east San Lorenzo, 01°05'36.8"N, 78°42'21.5"W: TTU???? (U).
San José farm 24 km east San Lorenzo, 01°00'36"N, 78°37'20"W: TTU???? (M).
Recinto Durango, Bloque Quijano; 01°07'00.2"N, 78°43'24.0"W: MECN2211 (F), MECN2239 (M), MECN2245 (M), MECN2238 (F), MECN2249 (F).
Tululbi,
Centro Comunal Mataje, North Awá Reserve, 01°04'00.0"N, 78°34'59.9"W: MEPN2050 (F), MEPN3673 (F), MEPN3700 (F).
Urbina,
Urbina, 01°02'N, 78°46'W: MEPN1931 (M), MEPN1932 (M).

SANTO DOMINGO DE LOS TSÁCHILAS (1)
Santo Domingo:
Luz de América,
Hacienda San Antonio, km 42, Road Santo-Domingo-Quevedo, 00°31'32.0"S, 79°19'21.0"W: MIZI2012397 (M).

APPENDIX 2

Meaning of acronym used in Table 1, for explain how to measure them see Velazco (2005) and Velazco & Gardner (2009)

HB = Head body length; F = foot length; E = ear length; FA = forearm length; W = weight expressed in mm; GLS = greatest length of skull; CCL = condylocanine length; CIL = condyloincisive length; BB = braincase breadth; ZB = zygomatic breadth; PB = postorbital breadth; MB = mastoid breadth; PL = palatal length; MLTRL = molariform toothrow length; MTRL = maxillary toothrow length; M1-M1 = width across first upper molars; M2-M2 = width across second upper molars; MXBR = breadth across maxillae; C-C = palatal width at canines; DENL = length of dentary; MANDL = length of mandibular toothrow; COH = coronoid height.

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