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Biogeographic pattern and potential distribution of *Glossophaga valens* Miller, 1913 (Chiroptera: Phyllostomidae)

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Glossophaga valens is a generalist nectar-feeding bat known from the western slopes of Ecuador and Peru. Recently elevated to species level, key information about its geographic boundaries and environmental preferences remains limited. We developed a niche-based species distribution model to describe its biogeographic pattern, delimit its distribution, and evaluate its potential range. We compiled 107 occurrence records from scientific literature and museum collections, covering the complete known distribution of the species. After curating these data, 83 high-quality and spatially independent records were combined with five bioclimatic variables to build a model using the Maxent algorithm in the Wallace software. The best-performing model was selected from 50 candidates based on lower complexity criteria. Our results indicate that *G. valens* exhibits a nearly continuous distribution with high to very high suitability along the Pacific coast of Ecuador and Peru, while isolated conditions occur in northeastern Peru. Our findings update the marginal localities for the species and highlight its strong preference for arid to semi-arid conditions in western lowlands below 1500 m. The model refines the species' range, placing its northernmost boundary in Esmeraldas, Ecuador, and suggesting its absence from Colombia. It also suggests that its southern limit could extend from southern Arequipa to northern Chile, pending future surveys and specimen revisions. Additionally, we report new easternmost records in northeastern Peru, aligning with the Marañón Valley. Key geographic features such as Seasonally Dry Tropical Forests, the Andes, and the Huancabamba Depression, alongside ecological traits like generalist feeding habits and adaptability, play a crucial role in shaping its distribution. Finally, we discussed how these geographic features have influenced the distribution of *G. valens* and other western Andean bats, and remark conservation implications in their threatened habitats.

Glossophaga valens es un murciélago nectarívoro generalista distribuido en las laderas occidentales de Ecuador y Perú. Recientemente elevado al nivel de especie, presenta limitada información sobre sus límites geográficos y preferencias ambientales. Desarrollamos un modelo de distribución de especies basado en su nicho para describir su patrón biogeográfico, delimitar su distribución y evaluar su rango potencial. Compilamos 107 registros de presencia a partir de literatura científica y especímenes revisados de colecciones de museos cubriendo toda la distribución conocida de la especie. Luego de depurar los datos, utilizamos 83 registros de alta calidad e independientes espacialmente junto con cinco variables bioclimáticas para construir un modelo empleando el algoritmo Maxent en el software Wallace. El mejor modelo en base a su desempeño fue seleccionado entre 50 candidatos a partir de un criterio de menor complejidad. Nuestros resultados indican que *G. valens* presenta una distribución casi continua con una idoneidad de hábitat de alta a muy alta a lo largo de la costa del Pacífico de Ecuador y Perú, mientras que en el noreste de Perú las condiciones son más aisladas. Nuestros hallazgos actualizan las localidades marginales de la especie y resaltan su marcada preferencia por condiciones áridas a semiáridas en tierras bajas occidentales por debajo de los 1500 m. El modelo refina su rango de distribución, estableciendo su límite norte en Esmeraldas, Ecuador, y sugiriendo su ausencia en Colombia. Asimismo, sugiere que su límite sur podría extenderse desde el sur de Arequipa hasta el norte de Chile, sujeto a futuras exploraciones y revisiones de especímenes. Además, reportamos nuevos registros más orientales en el noreste de Perú, que coinciden con el Valle del Marañón. Factores geográficos clave, como los Bosques Secos Estacionales, los Andes y la depresión de Huancabamba, junto con rasgos ecológicos como su dieta generalista y adaptabilidad, juegan un papel crucial en la configuración de su distribución. Finalmente, discutimos cómo estas características geográficas han influido en la distribución de *G. valens* y otros murciélagos andinos occidentales, y destacamos las implicancias de conservación en sus hábitats amenazados.

Keywords: Arid Environments, dry ecosystems, dry forest, Huancabamba, Marañón, species distribution modelling, zoogeography

Introduction

Long-tongued and nectar-feeding bats of the genus *Glossophaga* E´. Geoffroy St.-Hilaire, 1818 are endemic to the Neotropics. Members of this genus are characterized by their small size, brown to reddish-brown coloration, and a distinct interfemoral membrane with a short tail (Griffiths and Gardner 2008). Recent taxonomic revisions using geometric morphometrics elevated four taxa previously considered subspecies of *Glossophaga soricina* to full species status (Calahorra-Oliart *et al.* 2021). Consequently, nine species are recognized within the genus: *Glossophaga antillarum* Rehn, 1902; *G. bakeri* Webster and Jones, 1987; *G. commissarisi* Gardner, 1962; *G. leachii* Gray, 1844; *G. longirostris* Miller, 1898; *G. morenoi* Martínez and Villa-R., 1938; *G. mutica* Merriam, 1898; *G. soricina* (Pallas, 1766), and *G. valens* Miller, 1913 (Calahorra-Oliart *et al.* 2021, Simmons and Cirranello 2024).

Among these species, the Robust Long-tongued Bat, *Glossophaga valens*, is known to inhabit a wide range of ecosystems, including dry forest, fog oases, wetlands, urban areas and rural landscapes (Mena and Williams 2002; Pacheco *et al.* 2020; Mena *et al.* 2021). As a generalist nectarivore, *G. valens* feeds on pollen and fruits from native plants in natural ecosystems (Arias *et al.* 2009; Novoa *et al.* 2011), but it also demonstrates adaptability to exotic, cultivated plants in urban areas (Pellón *et al.* 2020). Described initially from Balsas, Cajamarca (Miller 1913), the species' type locality was later corrected to Amazonas Department by Ortiz de la Puente (1951). Its documented distribution range includes the western (Pacific) slopes of Ecuador and Peru, with additional populations in eastern inter-Andean valleys (Miller 1913; Webster 1993; Griffiths and Gardner 2008). Although Koopman (1978) suggested these disjunct populations might be connected via Andean passes in northern Peru, this hypothesis remains untested.

While previous studies have provided valuable insights into *Glossophaga valens*, many aspects of its distribution remain unknown. Hoffman *et al.* (2019) presented the first species distribution model for the species, focusing on its genetic and taxonomic relationships. However, their model excluded the eastern distribution and geographic limits of *G. valens*. More recently, Calahorra-Oliart *et al.* (2022) developed an ecological niche to explore abiotic requirements and morphological divergence among *Glossophaga* species. They revealed that *G. valens* occupies the driest conditions (e.g. lowest precipitation values and high precipitation seasonality in their habitats) within the genus but did not account for dispersal limitations, resulting in an overestimated potential range. Consequently, critical questions regarding the species' geographic boundaries, accessible areas, and the influence of geographic features remain unresolved.

Delimiting species distributions is essential for conservation efforts, offering tools to evaluate vulnerability, understand biodiversity patterns, and anticipate threats (Lamoureux *et al.* 2006; Mota-Vargas and Rojas-Soto 2012). Niche-based species distribution models (here in SDMs) have become indispensable for predicting distributions, elucidating species-environment relationship, and approximating the Grinnellian niche (Guisan and Thuiller 2005; Peterson *et al.* 2011; Soberón and Nakamura 2009). In Neotropical bats, SDMs have been extensively applied to refine species distributions, support taxonomic decisions, identify potential populations, evaluate conservation status, and enhance natural history knowledge (Velazco *et al.* 2018; Ramírez *et al.* 2020; Zegarra *et al.* 2020; do Amaral *et al.* 2023; Avila-Bernal *et al.* 2024; Otárola-Ardila *et al.* 2024). Considering that *Glossophaga valens* was historically reported on both slopes of the Andes in Peru (Koopman 1978), we hypothesized that SDMs could help to identify environmentally suitable corridors that may connect disjunct populations, especially in northern Peru. In this study, we compiled occurrence records of *Glossophaga valens* to 1) update its distribution and describe its biogeographic patterns, and 2) infer its potential distribution and environmental requirements. Additionally, we discussed the biogeographic and non-biogeographic factors shaping its current distribution.

Materials and methods

Occurrence data and morphological identification. We collected georeferenced occurrence records for *G. valens* from two primary sources: (1) localities associated with voucher specimens housed at the Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM), Lima, Peru, and (2) records extracted from peer-reviewed articles. Voucher specimens from MUSM were morphologically reviewed to ensure accurate identification, adhering to the morphological descriptions of Miller (1913) and the morphometric criteria provided by Calahorra-Oliart *et al.* (2021, 2022). The identification of *G. valens* was based on diagnostic cranial morphology, including an inflated braincase with an oblong shape (not domed as in *G. soricina*), long nasal bones, and a relatively large and wide rostrum (versus shorter and narrow rostrum in *G. soricina*). Dentition features included four subequal, highly procumbent upper incisors; four similarly shaped lower incisors; and three molars in each tooth row. The species' greatest length of skull (GLS) ranged from 21.5 to 22.8 mm, in contrast to GLS measurements below 21 mm in *G. soricina*. External characteristics distinguishing *G. valens* included a non-elongated rostrum (respect to other glossophagines), a developed uropatagium, pale gray coloration, and a forearm length exceeding 35.5 mm (compared to <35 mm in *G. soricina*).

In addition to MUSM vouchers, we incorporated records from Males-Andocilla's (2019) thesis, as the identifications were based on voucher specimens consistent with our criteria for *G. valens*. Locality details of this last source were taken from online database of the mammal collection of the Museum of Zoology QCAZ (Pontificia Universidad Católica del Ecuador). Comparative analysis with voucher specimens of *G. soricina* and *G. bakeri*, also housed at MUSM, further supported accurate identifications (Appendix 1). Additionally, we searched the Global Biodiversity Information Facility (GBIF 2025) for occurrence records, but as of 2025, some records are mislabelled as *Glossophaga soricina*, and both species (with *G. valens*) could be externally misidentified, we opted for using records from vouchers which were available to confirm by key cranial and external characters, and for those whose identification have been already confirmed in the literature. Final dataset is provided in Appendix 1.

Cleaning occurrence records. For localities with incomplete geographic data, coordinates were assigned using a combination of label information, Google Earth Pro v. 7.3.6.10201, and gazetteers provided by Gardner (2008). This process ensured that all records were accurately georeferenced. To maintain data quality, we curated the dataset by excluding duplicate records, removing zero or erroneous coordinates, and addressing spatial biases using the *clean_coordinates* function from the *CoordinateCleaner* package (v3.0.1; Zizka *et al.* 2018) in R software (R Core Team 2022). This cleaning process ensured the reliability of the occurrence data for subsequent analyses.

To minimize sampling bias during the modeling species distribution, we employed the spThin package (Aiello-Lammens *et al.* 2015) integrated within Wallace v. 2.1.1, a platform for reproducible modelling of species niches (Kass *et al.* 2018, 2023). This tool filters occurrence records based on a user-defined minimum distance threshold to reduce spatial autocorrelation (the similarity of nearby locations in terms of a given variable, which can bias model predictions). A threshold of 5 km was selected, reflecting the dispersal capacity of a closely related species, *Glossophaga soricina*, in arid ecosystems (Aguiar *et al.* 2014). After completing these steps, the final dataset consisted of 107 georeferenced occurrence records, of which 83 spatially independent records were retained for SDM construction (see below).

Environmental data. We obtained climate data from WorldClim v. 2.0 (Fick and Hijmans 2017) at a spatial resolution of approximately 1 km^2 (0.0083 degrees). To establish the calibration area for the species distribution model, we created buffers around the species' occurrence points with a radius of 2.5°. This distance was selected to encompass a natural environmental gradient that includes suitable habitats (*e. g.* dry forests and coastal deserts based on the high number of records), transitional zones where the species is less frequent (*e. g.* inter-Andean valleys), and areas where its presence is highly unlikely (*e. g.* high lands of Puna ecosystems above 3000 m). This approach allows the model to explore a full range of environmental conditions without relying on artificial political boundaries, and without overestimating the accessible area, thus providing a reasonable extent for extrapolating the species' potential distribution. Buffers were generated using the *terra* package v. 1.7 (Hijmans 2024) in R (R Core Team 2022). Within this area, we selected independent predictors based on two criteria: (1) variables with low intercorrelation ($r < 0.7$) to avoid multicollinearity and (2) variables that effectively explain the species' climatic preferences. A Pearson correlation analysis was performed using the *corrplot* package (Wei and Simko 2021) in R, and a correlation matrix was constructed to identify and exclude highly correlated variables.

As a result, five bioclimatic variables were retained for the final dataset: BIO4 (Temperature seasonality, °C), BIO7 (Temperature Annual Range, °C), BIO8 (Mean Temperature of Wettest Quarter, °C), BIO12 (Annual Precipitation, mm), and BIO15 (Precipitation Seasonality, %). These variables were selected to capture the pronounced seasonality of dry and wet periods within the distribution range of *G. valens* and to reflect key climatic conditions relevant to their biology, especially the dry conditions the species can tolerate as temperature and precipitation fluctuations can influence their physiological performance, and foraging activity. All bioclimatic variables were managed in raster format and georeferenced using the WGS84 datum.

Niche–based species distribution modelling (SDM). We employed a non-spatial random k-fold cross-validation approach, with a partition threshold of $k = 4$, to evaluate model accuracy. SDM were constructed using the maximum entropy algorithm implemented in Maxent (Phillips *et al.* 2006) via Wallace v. 2.1.1 (Kass *et al.* 2018, 2023). Model calibration involved selecting 10,000 randomly sampled pixels from the study area as background points. To optimize model configuration, we tested various feature type combinations, including linear (L), quadratic (Q), linear-quadratic (LQ), hinge (H), linear-quadratic-hinge (LQH), and linear-quadratic-hinge-product (LQHP). Additionally, nine values for the regularization multiplier, ranging from 0.5 to 5.0 in 0.5 intervals, were evaluated. To enhance robustness and avoid overfitting, models were generated without extrapolation or clamping, ensuring predictions remained within the environmental values of the training data. Thus, 50 candidate models were generated.

Model performance was assessed using the *ENMeval* package (Muscarella *et al.* 2014), integrated within Wallace v. 2.1.1 (Kass *et al.* 2018, 2023). We evaluate model complexity using the corrected Akaike Information Criterion (AICc), with preference given to models of lower complexity and correspondingly lower AICc values. Additionally, we assess model accuracy by the area under the curve (AUC), with an optimal threshold set at AUC > 0.8 to ensure robust predictive performance (Peterson *et al.* 2011).

The best-performing model was projected as a continuous suitability map using the Maxent cloglog transformation. Suitability values were then classified into four categories based on the 5-percentile presence threshold (0.22): Unsuitable: 0–0.22; low suitability: 0.22–0.50; high suitability: 0.50–0.80 and very high suitability: 0.80–0.99. The best-performing model was projected as a continuous suitability map using the Maxent cloglog transformation. Suitability values were then classified into four categories based on the 5-percentile presence threshold (0.22): Unsuitable: 0–0.22; low suitability: 0.22–0.50; high suitability: 0.50–0.80; and very high suitability: 0.80–0.99. Regions identified as potentially suitable but inaccessible were excluded from the final suitability map. We followed three criteria for this step: 1) areas geographically isolated and with lack of connectivity with the rest of the species' distribution, due to major geographic barriers such as the Andes, 2) lack of confirmed records; and 3) confirmed presence of *G. soricina*, a closely related species with no known sympatry with *G. valens*.

Results

Updated distribution and biogeographic pattern. We examined 176 specimens and confirmed 107 occurrence localities for *G. valens* based on museum vouchers and published literature (Figure 1; Appendix 1). Our examination reveals that *G. valens* exhibits a nearly continuous distribution between 1°N and 17°S along the western slopes of Ecuador and Peru, with disjunct populations in north-eastern Peru. Most records (97%) occur at elevations between sea level and 1500 m (Figure 1). However, we also report new noteworthy altitudinal records: 1920 m in La Libertad Department (Locality 84: MUSM 17203) and 1733 m in Amazonas Department (Locality 49: MUSM 1345, 1346). Notably, we document significant disjunct populations on the eastern slopes of the Andes in Amazonas, Cajamarca, and La Libertad Departments. These findings extend the known eastern distribution to the intersection of the Marañón and Utcubamba rivers (Figure 1). All records from Ecuador are restricted to the western slopes of the Andes. The complete revised dataset of *G. valens* occurrence records are provided in Appendix 1.

Marginal occurrence records were identified at the northern and southern limits of the species' range. The northernmost record is in Esmeraldas Province, Ecuador (Locality 1: QCAZ 6716), while the southernmost record is in Arequipa Department, Peru (Locality 107: Webster, 1983, 1993). Most records are situated at sea level along the coast in Ecuador and Peru. In Ecuador, the easternmost records include Los Ríos Province (Locality 6: QCAZ 8909) and Bolívar Province (Locality 10: QCAZ 469, 471, 472). In Peru, the easternmost records are concentrated along the Marañón Valley, extending to the intersection of the Chinchipe, Marañón, and Utcubamba rivers in Cajamarca and Amazonas Departments (Localities 49 and 54: MUSM 1345, 1346, 56482; Appendix 1), approximately 217 km inland from the Pacific coast.

Niche-based species distribution model. The selected model, chosen from 50 candidate models, exhibited strong predictive performance with a feature class combination of LQH, a regularization multiplier of 1.5, and 14 coefficients (AUC_{train}: 0.916, $AUC_{val.avg}$: 0.895, AICc: 2098.31, ΔAICc: 0). This model demonstrated lower complexity compared to other candidates, achieving an optimal balance between accuracy and simplicity (Appendix 3).

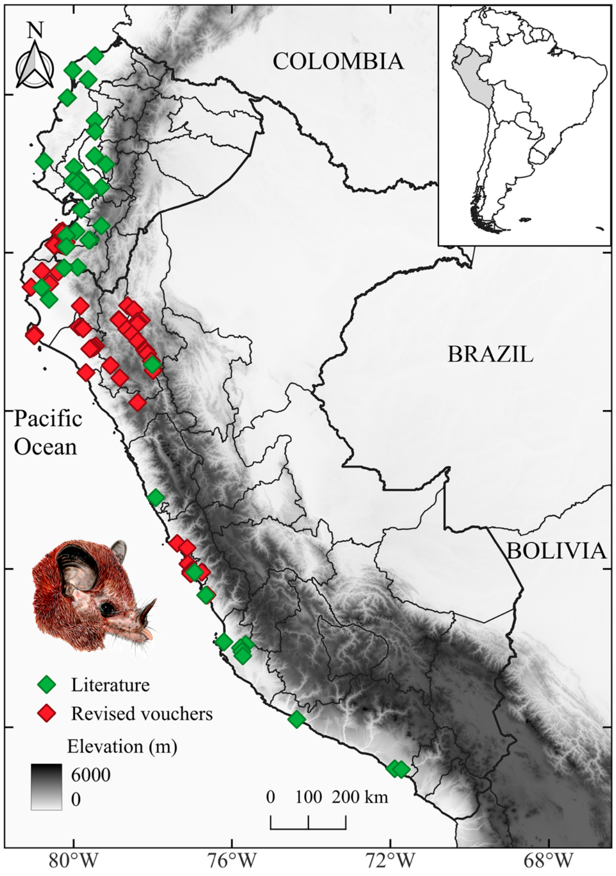

Figure 1. Occurrence records of the Robust Long-tongued Bat (*Glossophaga valens*). Red points indicate localities supported by revised voucher specimens, whereas green points correspond to localities extracted from the literature.

Predictions indicated that *G. valens* exhibits high to very high habitat suitability (suitability > 0.5) under specific environmental conditions. Important predictors selected through Wallace included temperature seasonality (BIO4) below 100 CV (%), temperature annual range (BIO7) below 15°C, and annual precipitation (BIO12) below 1200 mm. Additional factors such as mean temperatures of the wettest quarter (BIO8) above 0°C and precipitation seasonality (BIO15) over 27 CV (%) are also related to high suitability (Figure 2).

The predicted distribution of *G. valens* is predominantly continuous along the western coastline of Ecuador and Peru, with a disjunct population on the eastern slopes of the Andes between Cajamarca and Amazonas Departments (Figure 3). From north to south, the model predicts high-suitability conditions in southern Esmeraldas Province but identifies unsuitable areas northward in Colombia (Figure 3a). High to very high suitability zones are concentrated along the Pacific coastlines of southern Ecuador and northern Peru (Figure 3).

The model also identifies high-suitability areas with few or no confirmed records (n), pointing to potential under-sampled regions, including Ecuador: Manabí (n = 2), Santa Elena (n = 1), Azuay (n = 2), and Loja (n = 2) Provinces. From Peru the Inter-Andean valleys in La Libertad (n = 2), Ancash (n = 1), and Ayacucho (n = 0) (Figure 3).

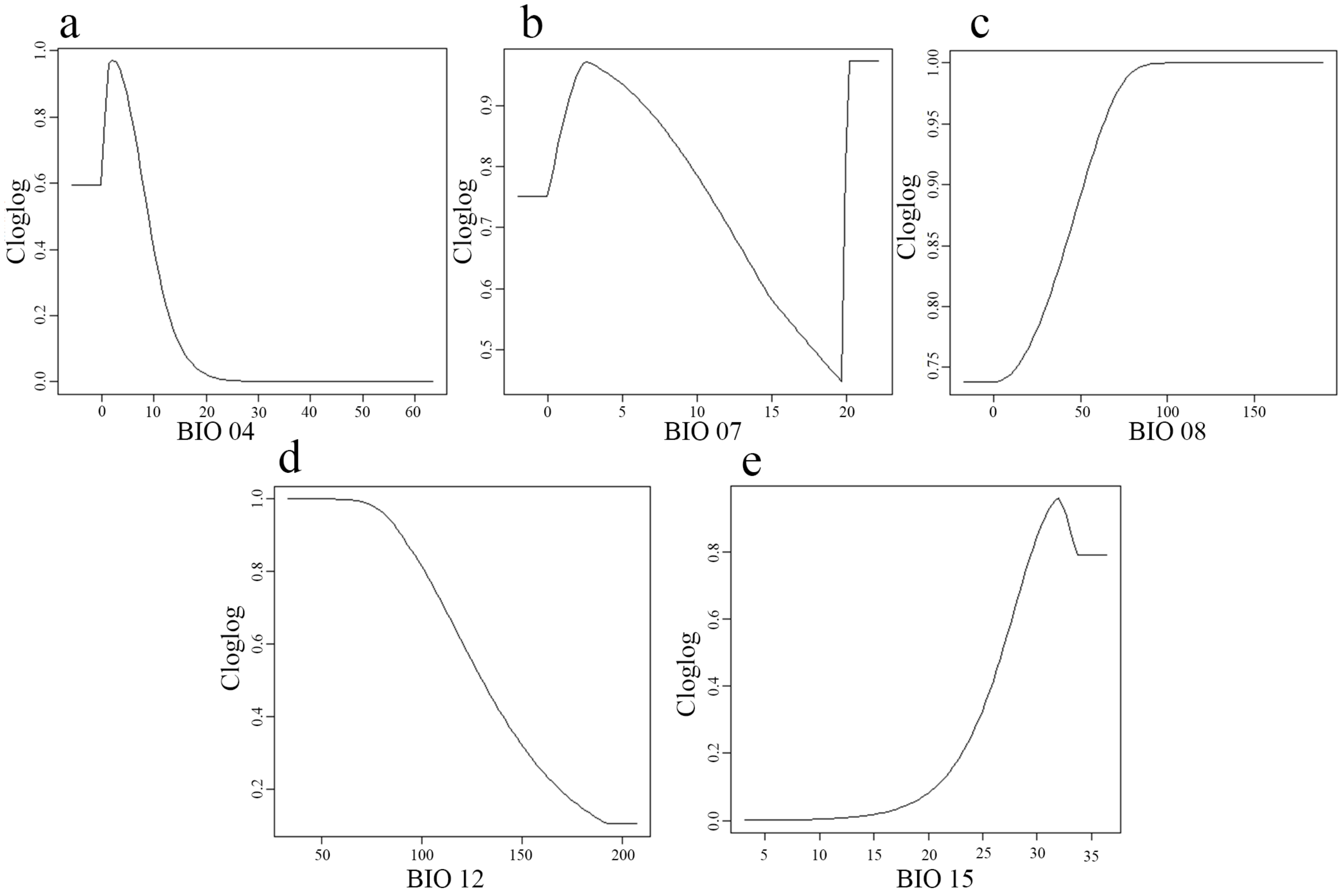

Figure 2. Response curves obtained for the selected optimal model for each selected variable: a) Temperature seasonality, °C (BIO4); b) Temperature Annual Range, °C (BIO7); c) Mean Temperature of Wettest Quarter, °C (BIO8); d) Annual Precipitation, mm (BIO2); and e) Precipitation Seasonality, % (BIO15).

In the Huancabamba Depression, located near 5–7°S, the model identifies areas of high suitability extending through the Marañón Valley. This valley is delineated by the Chamaya, Chinchipe, Marañón, and Utcubamba rivers (Figs. 3b, 4). Although the Marañón River extends northward, the predicted eastern distribution of *G. valens* terminates abruptly near the convergence of the Chinchipe, Utcubamba, and Marañón rivers (Figs. 3b, 4). A closer examination of this area reveals the truncation of its eastern range (Figure 4), with suitability values decreasing toward the east, coinciding with a shift from arid to more humid environments (Figure 4).

To the south, suitability values suggest the range of *G. valens* extends from Arequipa through Moquegua and Tacna in Peru to northern Chile (Tarapacá). However, confirmed records are lacking in these areas, requiring further field exploration (Figs. 1, 3c). Conversely, areas above 2000 m exhibit low suitability, supporting the hypothesis that the Andes act as a biogeographic barrier limiting the species' dispersal into the eastern slopes.

Discussion

Our study expands the known distribution of *Glossophaga valens*, incorporating notable museum-based records from the eastern slopes of Peru and providing a verified dataset of 107 localities for future geographic and conservation studies. Compared to previous analyses (Hoffman *et al.* 2019; Calahorra-Oliart *et al.* 2022), our approach integrated a larger dataset and accounted for dispersal limitations based on verified vouchers, producing an ecologically realistic model. The current records and SDM highlight a distribution predominantly within xeric lowlands (<1500 m) of the western slopes of Ecuador and Peru, as well as parts of the northeastern slopes characterized by low precipitation and high temperatures. These findings complement earlier geographic analyses of *G. valens* (Webster 1993; Calahorra-Oliart *et al.* 2022) and suggest that *G. valens* prefers environments characterized by low precipitation and relatively stable, high temperatures or typical dry conditions as found by Calahorra-Oliart *et al.* (2022).

Geographic limits and potential distribution. The geographic distribution of *G. valens* based on confirmed records extends from Esmeraldas Province in northern Ecuador to the Tambo Valley, Arequipa Department in southern Peru, with notable patterns at both limits. In the north, populations in Esmeraldas's match with high-suitability areas but are reduced in extent or spatially restricted to the south of this Province. Northward, unsuitable areas in Colombia delineate the northernmost limit of *G. valens* in Ecuador's Esmeraldas Province, also observed in other bats: the vesper bat, *Eptesicus innoxious* (Loaiza *et al.* 2020). Prevalent humid habitats in

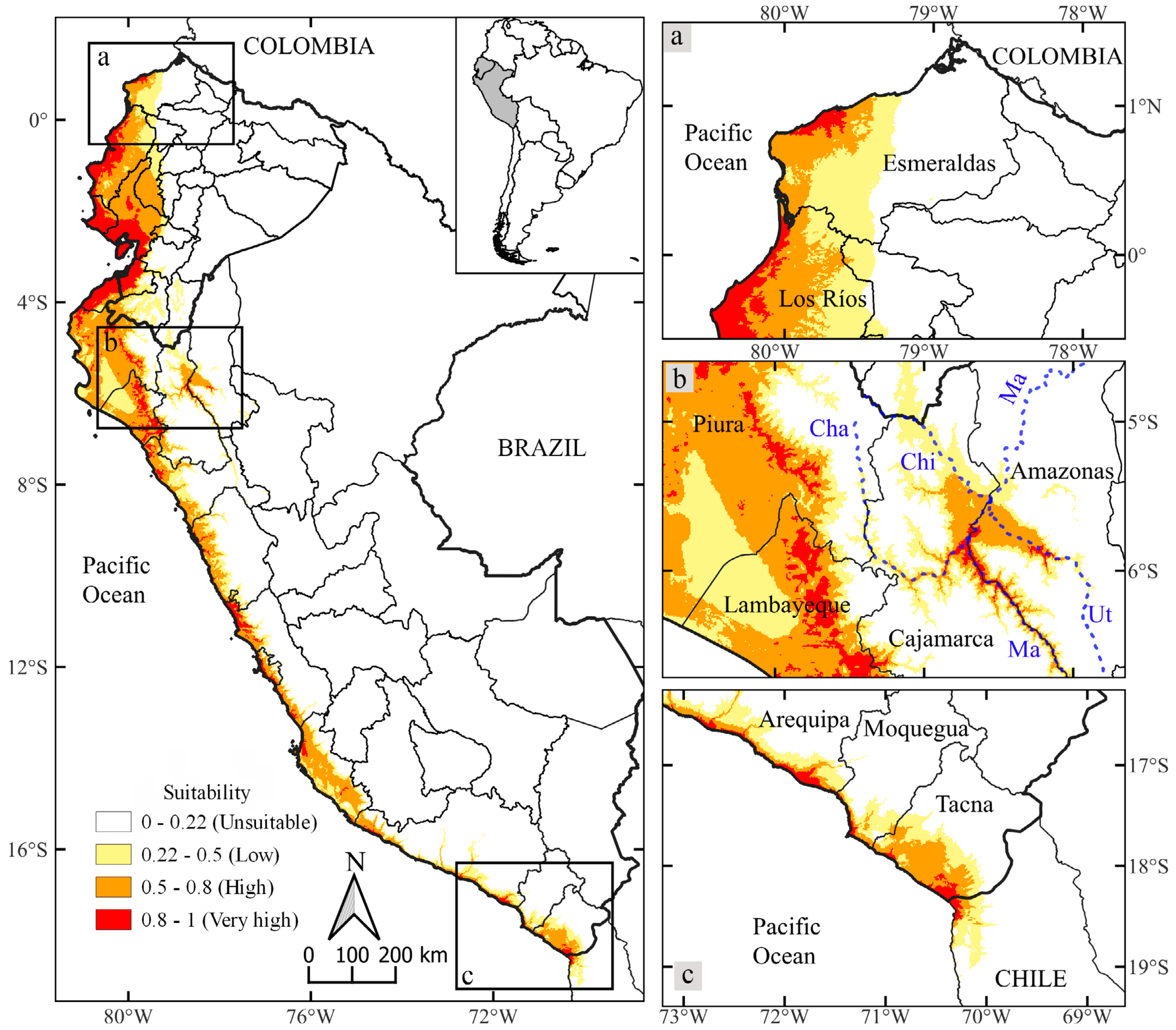

Figure 3. Niche-based species distribution model of *Glossophaga valens* displayed in four suitability categories: unsuitable, low, high, and very high. Insets highlight distribution limits and key geographic features: a) Northern limit, b) Eastern limit, and c) Southern limit. Rivers are denoted by blue dotted lines and include the Chamaya (Cha), Chinchipe (Chi), Marañón (Ma), and Utcubamba (Ut).

southwestern Colombia, part of the Western Ecuador moist forest ecoregion (Olson *et al.* 2002) limits its northward dispersion, a scenario also recorded in its easternmost distribution discussed posteriorly. While this pattern suggests that environmental conditions constrain the northern limit of *G. valens*, further studies are needed to evaluate the role of biotic interactions (*e. g.* presence of *G. mutica*; Calahorra-Oliart *et al.* 2022), resource availability, or historical factors such as orogenic events (Dias *et al.* 2017) or climatic fluctuations (as reported for other glossophagine species like *Anoura cultrata*; Molinari *et al.* 2023).

In the south, while the model predicts high suitability in Moquegua, southern Tacna, and northern Chile, bat surveys in Tacna (Aragón and Aguirre 2014; Lanchipa and Aragón-Alvarado 2018) and northern Chile (Ossa *et al.* 2016, 2018; Rodríguez-San Pedro *et al.* 2020) have not recorded *G. valens*. Given its status as a generalist nectarivore, commonly captured in both natural and urban ecosystems using mist nets (Pacheco *et al.* 2007, 2020; Pellón *et al.* 2020), its apparent absence southward may represent a sampling bias or a signal of low-density populations which evidence the need for further field surveys between southern Tacna and northern Chile. Interestingly, this apparent inability to colonize southern regions contrasts with the broader distribution of *Platalina genovensium*, a specialist nectarivore known to inhabit Tacna (Aragón and Aguirre 2014; Lanchipa and Aragón-Alvarado 2018) and northern Chile (Ossa *et al.* 2016; Ruelas and Pacheco 2018). This discrepancy raises questions about the factors restricting *G. valens*' geographical expansion.

In its eastern range, both abiotic and biotic factors seem to simultaneously act limiting the distribution of *G. valens*. While the species tolerates arid environments, its range abruptly ends in the humid lowlands of northern Amazonas.

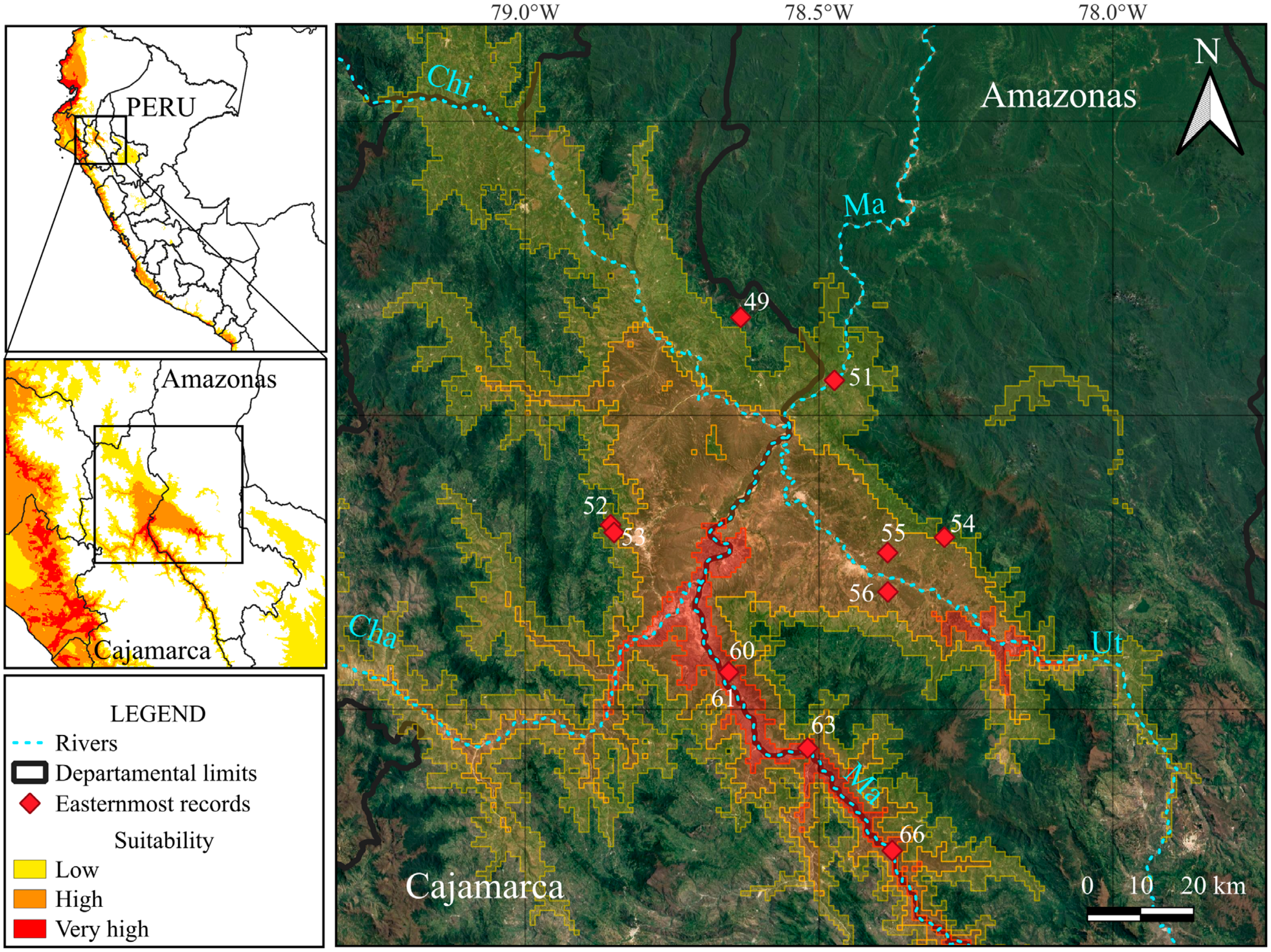

Figure 4. Eastern distribution of *Glossophaga valens* showing new easternmost records and predicted suitable areas. The map illustrates the truncation of the species' potential range across the transition from the arid Marañón valleys to the northern lowland Amazon. Key new records are numbered according to Appendix 1. Rivers are shown as blue dotted lines: Chamaya (Cha), Chinchipe (Chi), Marañón (Ma), and Utcubamba (Utc), highlighting the role of river systems and valley aridity in shaping the species' eastern range.

This truncation aligns with a shift in climatic conditions, transitioning from dry shrublands and forests to humid rainforests as shown in Figure 4. Notably, this transition occurs at the intersection of the Chinchipe, Utcubamba, and Marañón rivers, where the model shows a sharp decline in suitability. These rivers, which delineate the Marañón Valley, may also function as biogeographic boundaries or corridors influencing population connectivity. Moreover, northward in Amazonas, *G. soricina* becomes the only *Glossophaga* species (see vouchers and detailed localities in Appendix 2), suggesting potential competition and ecological exclusion. Such pattern aligns with findings indicating that non-suitable areas act as barriers to gene flow and contribute to species divergence (Calahorra-Oliart *et al.* 2022). Further studies are needed to explore and determine possible contact zones and interbreeding between *G. valens* and *G. soricina*.

In Peru, the Seasonally Dry Tropical Forest (SDTFs) of the Huallaga valley, located on the eastern slopes of the Andes, was initially recognized by the model as areas with low to high suitability for *G. valens*. However, this area was excluded from the final distribution due to its inaccessibility, lack of connectivity with the rest of *G. valens*' range, and the confirmed presence of *G. soricina* (Ruelas and Pacheco 2021). Additionally, Webster (1993) recorded a voucher (catalog number not detailed) housed in the Louisiana Museum of Natural History, collected from San José, Rio Santa Rosa, Ayacucho Department. Although the initial model predicted low suitability areas along the Apurímac Basin in Ayacucho, these regions were excluded due to their isolation, inaccessibility, and confirmed absence of *G. valens* based on recent bat surveys, which recorded only *G. soricina* (Ramos-Ascue *et al.* in prep.). As previously mentioned, the presence of *G. valens* in Ayacucho is anticipated, but restricted to the western inter-Andean valleys. Further field surveys and specimens' revisions are recommended to confirm the identity of individuals assigned to *G. soricina* in the eastern Huallaga Valley and lowlands of the Apurímac River basin as they may represent distinct populations adapted to arid conditions, in contrast to the typical humid habitats where *G. soricina* occurs.

Factors explaining current distribution of G. valens. The distribution of *G. valens* is shaped by two key geographic features: the Seasonally Dry Tropical Forests and the Andes. High suitability areas coincide with the SDTFs, particularly in coastal Ecuador and northern Peru, where the "Bosque Seco Estacional" (a Peruvian term for SDTFs, *sensu* Britto

2017) extends across both western and eastern slopes (Escribano-Avila *et al.* 2017; León *et al.* 2007; Britto 2017). This affinity for arid environments is further supported by field studies. Pacheco *et al.* (2007) reported *G. valens* (reported as *G. soricina*) exclusively in Equatorial dry forest habitats. This pattern was later confirmed by Cadenillas (2010), who, despite extensive sampling effort in Equatorial dry forests, Pacific tropical rainforest, and transitional areas between these habitats, noted a significant decline in *G. valens* abundance along the transition from dry tropical forest to Pacific tropical rainforest, with the species being dominant in the former. These findings align with our model's high suitability predictions for SDTFs and underscore the species' preference for xeric conditions.

Within this region, the Huancabamba Depression—an area of deflection in the northern Andes with its lowest point at 2150 m in Abra Porculla—is characterized by low mountain passes with arid and semi-arid conditions (Patterson *et al.* 1992) and likely connects both disjunct populations, as evidenced in the model, suggesting a corridor role for the colonization of Marañón Valley by *G. valens*. South of the Huancabamba Depression, along the western slopes of the Andes between sea level to 2500 m, the extent of the "Desierto Costero Tropical" and the "Matorral Desértico – Bosque Seco" (*sensu* Britto 2017) provides arid to semi-arid climatic conditions explaining the high to very high suitability values and high occurrence records in this area. At higher elevations, both north and south of the species' range, humid cloud forest and Altiplano highlands dominate (Weberbauer 1945; Koepcke 1954; Valencia 1992). These environments, which exhibit low to null suitability values, likely impose physiological limitations acting as a barrier to east-west dispersal and limiting the range of *G. valens*. We recommend further ecological studies to identify the abiotic and biotic factors (*e. g.* roosting sites and food availability) in the dry tropical forest and deserts inhabited by *G. valens* that strongly influence its fitness and determine the occurrence of *G. valens*.

This interplay between geographic features and physiological constraints also influences other bat species. For example, the restricted ranges of *Eptesicus innoxius, Rhogeessa velilla, Myotis moratellii, M. diminutus, Cynomops kuisha*, and *Lophostoma occidentalis* are similarly shaped by the SDTFs and the Andes (Velazco and Cadenillas 2011; Burneo and Tirira 2014; Moratelli and Wilson 2015; Loaiza *et al.* 2018; Novaes *et al.* 2021; Arenas-Viveros *et al.* 2021). Moreover, the bat assemblage distributed along the Peruvian western slopes from north to south, including *G. valens*, *Amorphochilus schnablii, Mormopterus kalinowskii, Nyctinomops aurispinosus,* and *Platalina genovensium* (Llancachahua-Tarqui *et al.*, 2023), highlights the role of geographic features (*e. g.* the Andes, the extent of dry tropical forest and western desert) in shaping species distribution. Additionally, the Huancabamba depression has also been suggested as a corridor for other bats (*e. g.* *Artibeus fraterculus, Tadarida brasiliensis*) and even birds (Chapman 1926; Patterson *et al.* 1992; Zegarra *et al.* 2020). Furthermore, this corridor role is consistent with geographic patterns observed in other bat species like *Amorphochilus schnablii, Lonchophylla hesperia,* and *Platalina genovensium,* which, are distributed on the eastern slopes despite primarily inhabiting Pacific lowlands (Tirira *et al.* 2011; Ruelas and Pacheco 2018; Guerra *et al.* 2020; Avila-Bernal *et al.* 2024).

The role of biotic factors in *G. valens* needs to be further investigated, as they may influence its occurrence and persistence, and thus play a key role in shaping its distribution. For example, the adaptability of *G. valens* to urban ecosystems appears to be relevant, as areas of high suitability overlap with cities such as Guayaquil, Lima, and Piura, where the species thrives in human-modified landscapes. Its ability to feed on exotic plants (Pellón *et al.* 2020), tolerate light pollution (Mena *et al.*, 2021), and use human structures like abandoned mines and old buildings as roosts (Ortiz de la Puente 1951; Bonifáz *et al.* 2020; Quispe-López *et al.* in prep.) highlights its ecological plasticity. Additionally, Cadenillas (2010), who conducted bat surveys in northern Peru, documented a significant increment in *G. valens* (reported as *G. soricina*) relative abundance in areas affected by cattle, reinforcing the species' capacity to inhabit disturbed habitats. As our findings reveal highly suitable habitats with several records in both natural (northern dry forest) and urban areas, comparative genetic and ecological studies are needed to assess potential differences between populations inhabiting these contrasting habitats. Such research could clarify how urbanization impacts the species' fitness and whether its capacity to exploit cultivated exotic plants (Pellón *et al.* 2020) contributes to its persistence in urban environments. It is important to emphasize that anthropogenic impacts are species-specific (Russo and Ancillotto 2014), and the observed adaptability of *G. valens* should not be extrapolated to other bats or sympatric biota.

Last remarks. The geographical distribution of *G. valens* reflects its evolutionary history shaped by abiotic conditions, biotic interactions, and geographic features such as SDTFs, the Andes, and the Huancabamba Depression (Feng *et al.* 2024). This distribution aligns with the hypothesis of a Central American origin, followed by dispersal along the western slopes of Ecuador and Peru and eventual establishment on the eastern slopes of the Peruvian Andes (Dias *et al.* 2017).

By refining the distribution boundaries of *G. valens* and identifying key areas of high environmental suitability, this research provides critical insights for guiding future survey efforts in regions where the species is likely to occur. Priority regions include areas with few to null records but with high predicted suitability, such as under-sampled inter-Andean valleys, northeastern Peru (a potential contact zone with *G. soricina*), southern Colombia (to refine boundaries with *G. mutica*), and southern Peru in Tacna and northern Chile.

Our findings have important conservation implications for *Glossophaga valens* whose distribution is closely tied to SDTFs, Pacific deserts, and inter-Andean valleys along the western slopes of Peru and Ecuador. This region represents one of the most distinctive areas of endemism for South American bats (Koopman 1982), hosting endemic species that are either known from only a few localities (*e. g. Histiotus mochica*, *Myotis bakeri*; Velazco *et al.* 2021; Llancachahua-Tarqui *et al.* 2023) or are classified under threatened categories (*e. g. Amorphochilus schnablii*, *Artibeus ravus*, *Cynomops greenhalli*, *Platalina genovensium*) (SERFOR 2018). Moreover, the Tumbesian region, (also termed SDTFs), which encompasses a great portion of western Ecuador and northwestern Peru, supports habitats for over 900 species of plants and vertebrates, 18% of which are endemic (Escribano-Avila *et al.* 2017). However, this region is also among the most threatened terrestrial biomes in the tropics, facing accelerated loss of vegetation cover due to human activities (Hoekstra *et al.* 2005; Miles *et al.* 2006).

Finally, with its elevation to the species level (Calahorra-Oliart *et al.* 2021), *G. valens* currently lacks a formal conservation status. Despite the ecological plasticity discussed earlier, its presence in fragile ecosystems such as coastal wetlands (Pacheco *et al.* 2015, 2020), fog oases (Bonifáz *et al.* 2020), and dry forests (Pacheco *et al.* 2007) underscores the urgency of assessing their populations in natural ecosystems as many of these ecosystems are undergoing rapid degradation. In this context, our revised and verified occurrence list, coupled with the identification of high-suitability areas, provides a critical foundation for guiding future research and conservation strategies. These include targeted field surveys in data-deficient regions, evaluations of habitat connectivity and gene flow, and a formal assessment of the species conservation status. This information is crucial for decision-makers aiming to implement effective conservation strategies in highly threatened habitats where *G. valens* occurs.

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Appendix

Appendix 1-3 are available at https://zenodo.org/records/15366252