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First record of Slender-billed Xenops (*Xenops tenuirostris*) from the Belém Region of Endemism: implications for its distribution in the Amazon

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ABSTRACT

Here, we report the first documented record of the Slender-billed Xenops, *Xenops tenuirostris* Pelzeln, 1859 in the Belém Region of Endemism. A Slender-billed Xenops was collected in March 2024 on the right bank of the lower Tocantins River, in southeastern Brazilian Amazonia, in the state of Pará. In addition to this collection, we modeled the potential distribution of this species to better understand current distribution limits and potential influences of climate change and deforestation in the near-future. We modeled three scenarios: 1) present (1970–2000 average), 2) future (2041–2060) with lower global warming and 3) with greater global warming. We used uncorrelated variables for modeling with MAXENT. Models indicate a decrease in distribution limits and a change in the distribution area, losing suitable areas in the north and northwest, and continued and increasing area in the central south and southeast of the Amazon, with areas for potential occurrence of the species concentrated in the arc of deforestation. These results suggest that over the next forty years the distribution of the Slender-billed Xenops will decrease.

KEYWORDS: arc of deforestation, niche modeling, passerine birds

Primeiro registro do bico-virado-fino (*Xenops tenuirostris*) no Centro de Endemismo Belém: Implicações para sua distribuição na Amazônia

RESUMO

Neste trabalho reportamos o primeiro registro documentado do bico-virado-fino (*Xenops tenuirostris*) no Centro de Endemismo Belém, sudeste da Amazônia brasileira, município de Mocajuba, margem direita do baixo rio Tocantins, no estado do Pará, em março de 2024. Além deste registro documentado, modelamos a distribuição potencial da espécie para entender melhor os atuais limites de distribuição e como eles podem ser influenciados pelas mudanças climáticas e pelo desmatamento em um futuro próximo. Modelamos a distribuição potencial de *X. tenuirostris* usando três cenários: presente (1970-2000), futuro (2041-2060) com menor aquecimento global e com maior aquecimento global. Testamos as variáveis para correlação usando a função vifstep do pacote usdm do R e o subconjunto de variáveis restantes foi usado para modelagem usando o algoritmo MAXENT. Os modelos indicam que as áreas potenciais para ocorrência da espécie estão concentradas no arco do desmatamento e sugerem que nos próximos quarenta anos *X. tenuirostris* poderá diminuir sua área de distribuição.

PALAVRAS-CHAVE: arco do desmatamento, modelagem de nicho, passeriformes

Limits to species distributions are complex, and to understand how the environment, including climate change, influences them over broad geographic scales we must also document encounters with species in new geographic locations (range extensions). This information helps answer questions regarding geographic variation in biodiversity and assessment of the impact of environmental change on subsequent extinction risk and inform conservation practices. In extremely biodiverse regions, such as the Amazon Basin of South America, field studies greatly under-represent the total area and number of species studied (Lees et al. 2020), and so gathering additional information and new geographic records continues to be important.

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The Slender-billed Xenops (*Xenops tenuirostris*, Passeriformes, Xenopidae) inhabits Amazonian Forest edges and the canopy (Remsen 2020). It is a small bird (10 cm, 9-11 g) that usually forages in the canopy with mixed-species flocks and is described as behaving like other *Xenops* species (Remsen 2020). Similar in appearance to the sometimes sympatric Streaked Xenops (*X. rutilans*), it can be distinguished from that species by its longer and slightly more slender bill, more black on tail, and sparser streaking below. The Amazonian Plain-Xenops (*X. genibarbis*), also rarely sympatric, is less streaked than both the preceding species. All *Xenops* sp. are insectivorous and forage climbing up tree trunks and on all sides of branches. The Slender-billed Xenops' song is a "simple series of shrill, evenly pitched notes" (Remsen 2020). Its ecology is poorly known because it is uncommon, difficult to observe and identify in the field, and is often confused with closely related species when sympatric. Where all three *Xenops* species and *Microxenops* occur in sympatry in southern Amazonia (*e.g.*, near the city of Alta Floresta in the state of Mato Grosso), *X. tenuirostris* was the last to be reported (Lees et al. 2013).

The Slender-billed Xenops has been found in much of the Amazon Basin (Rego et al. 2024) but is often overlooked due to its inconspicuous habits and easily-missed vocalizations. This xenops has never been reported east of the Xingu River, in the extreme southeast in the biogeographic area known as Belém Region of Endemism (Pará and Maranhão, Figure 1). One unverified record was in the Gurupi Biological Reserve, in the state of Maranhão (https://ebird.org/checklist/S14793188). Gaps in its distribution suggest either true absences or unobserved presences. Here, we document the first record of *X. tenuirostris* in the Belém Region of Endemism (Cracraft, 1985), thereby expanding its geographic distribution to the east of the Tocantins River. We also model the distribution of the species to predict where it may yet be found, and discuss whether the species should be considered threatened instead of Least Concern by the IUCN.

Field record – On 9 March 2024, one individual of *X. tenuirostris* was collected on the eastern side of the Tocantins River (Figure 1), in the municipality of Mocajuba (2.6692 S, 49.5730 W) (Figure 2). The bird was at the edge of low secondary *terra firme* forest (15 m canopy height). The specimen was deposited in the ornithological collection at the Federal Rural University of Pernambuco, Serra Talhada campus (UAST 757, data on specimen label: chestnut iris, maxilla light gray, mandible: pinkish and distal-half grey, tarsus dark grey, no bursa, no molt, lots of body fat, and stomach with Arthropoda, indeterminate sex). Permits for the collection of specimens were provided by IBAMA (Instituto Brasileiro do Meio Ambiente - number: 45640-6) and CEUA (Ethic Committee on Animal Use of the Federal Rural University of Pernambuco – number: 6308311023).

Niche modeling – Occurrences for the Slender-billed Xenops were obtained from confirmed vocalizations from Xeno-Canto (https://xeno-canto.org/) or photographs from WikiAves (https://wikiaves.com); both websites are free tools for online publication of observations of Brazilian birds and museum collections (Rego et al. 2024). We used a total of 19 bioclimate variables with a pixel resolution of 30" (~ 0.9 km² pixel^{-1})

Figure 1. Specimen of *Xenops tenuirostris* collected on the eastern bank of the lower Tocantins River.

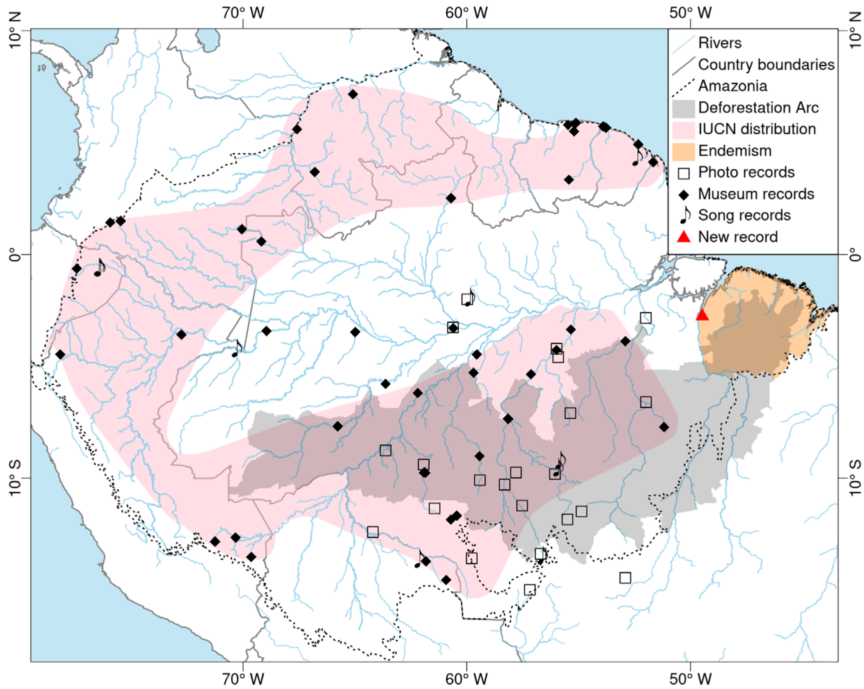

Figure 2. Map showing the current IUCN distribution of the Slender-billed *Xenops tenuirostris*, the arc of deforestation, and sampling sites used in this study for niche modeling (details in Table 2). The location of the new distribution record for the Slender-billed *Xenops* is indicated by the red triangle.

from Worldclim 2.1 (https://www.worldclim.org/; Fick and Hijmans 2017, Global Climate Models-GCMs, MIROC, Tatebe et al. 2019), plus a categorical vegetation layer for the present (Projeto MapBiomas) and another for the future (Chen et al. 2022) data. The most influential environmental variables to be used in the model were selected using the Jackknife test (Phillips et al. 2006; Phillips and Dudik 2008; Table 1). We used the recommendations of Pearson et al. (2007) in MAXENT 3.4.4, with 10 repetitions, regularization multiplier = 1, and 500 maximum iterations, on which maps were based on the average values of the repetitions (Pearson et al. 2007). We modeled potential distributions using three scenarios: 1) present (years 1970 to 2000 average), future (years 2041 to 2060) with 2) less warming (SSP 126) and 3) with greater warming (SSP 585; Eyring et al., 2016). We controlled for multicollinearity using the *vifstep* function of theusdm package (version 2.1-7, Naimi et al. 2014) in R (version 4.2.2). This stepwise function was used to exclude all variables with variance inflation factor (VIF) > 10 and the subset of remaining variables were used with the MAXENT algorithm (Phillips et al. 2006; see Table 1). The area of the geographical range in each distribution model with the mean raster from all raster layers was estimated from the Maxent analysis. This mean raster was then converted to binary (each pixel became 0 if its value was < 0.5, and 1 if ≥ 0.5) and the total area for each value was calculated using the expanse function in the terra package (version 1.7-71) in R. We used the AUC (the default for Maxent) to evaluate and compare models. An area was suitable for the species if the binary value = 1.

A total of 82 records were obtained for the Slender-billed Xenops (Figure 1, Table 2): 22 from WikiAves, 9 from Xeno-Canto, 1 from B. Whitney (pers. com.), and 49 from museum collections (Rego et al. 2024), plus our new record. We modeled its distribution for the present with and without our record to examine how it would change our estimates of the impact of climate and vegetation changes. The modelled distribution of the present (fundamental niche, 1970–2000

Table 1. Variables, and their relative importance and contributions, included in the best-fit model to explain and predict the geographic distribution for *Xenops tenuirostris* in decreasing order of importance. Contribution is how much a variable adds to the explanatory power of the model, and, as percentages, allows them to be compared among themselves.

Variable	Contribution (%)	Importance
Vegetation	32.1	17.1
Precipitation of Wettest Month	18.7	14.4
Precipitation of Coldest Quarter	10.2	7.8
Isothermality	9.5	13.1
Precipitation of Warmest Quarter	6.6	7.2
Mean Diurnal Range of Monthly (max temp - min temp)	6.4	4.4
Precipitation of Driest Month	5.8	10.3
Max Temperature of Warmest Month	5	8.7
Temperature Seasonality	4.2	8.9
Precipitation Seasonality	1.5	8.1

average) is concentrated in the south of the Amazon, with 63 records (57% of all records). Total estimated suitable area at present and with this new record is 1,679,762 km^2 (without is 1,498,442 km^2. In the less-warming future (2041–2060), the distribution of adequate climate will decrease by 125,078 km^2 (~7% decrease with less warming). In the more-warming future, it will decrease by 311,679 km^2 (19% decrease with more warming) (Figure 3). The future geographic distribution with adequate climate for Slender-billed Xenops includes the Brazilian "arc of deforestation," where extensive deforestation is occurring in the Brazilian Amazon (Figure 2).

Conservation implications – The absence of records for the Slender-billed Xenops east of the Xingu and Tocantins rivers may be due to it being less abundant there, considering that the region is not less studied than others with more records. Due to behavior, we consider a long-range dispersal event to be unlikely. It is also unlikely that birds were released in the region after being translocated by IBAMA, which historically released birds that were trafficked or captured in association with major infrastructure projects. Also, due to its similarity with other species, it may have been misidentified in some studies. Thus, we suggest that the range is continuous and includes the new record, but abundance may be quite variable.

Models suggest a reduction and changes in the geographic distribution of the xenops following increased temperatures. Area in the north and northwest will be lost, while the central south and southeast of its distribution will be maintained and in some few places increase. Unfortunately, some area for its future distribution will be within the "arc of deforestation." If deforestation trends continue at the rates of today, over the next 40 years the range of the Slender-billed Xenops will decrease (Figure 2). Models of the current geographic distribution (with and without this new record) predict a lower probability of occurrence in the eastern Amazon. However, in the future the region is predicted to become an area more likely to be occupied by the xenops. If so, the modeled area for the Slender-billed Xenops will increase, but the increase will be in an area with rapid deforestation. Because the predicted distribution of the Slender-billed Xenops is included within the arc of deforestation, our results suggests that deforestation will cause an important additional loss of area (adding to the 311,679 km^2 lost to climate change in the higher warming scenario, or 18.6% for 2040-2060). This will result in the loss of ~10% of their suitable habitat within nine years. The IUCN Red List criteria (IUCN 2021) for Near Threatened (NT) status is applied when loss is >30% of suitable habitat within a maximum of three generations or nine years for this xenops (for passerine birds, considering

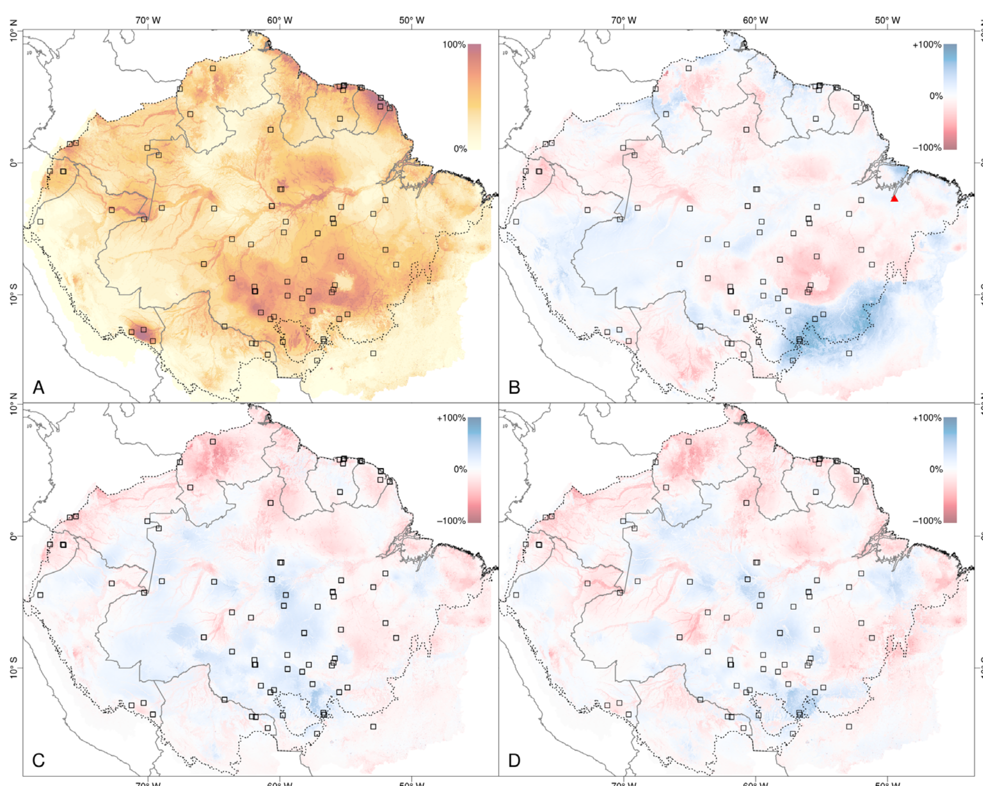

Figure 3. Maps showing habitat and climate suitability (A) and change in suitability (B, C, D) for the Slender-billed *Xenops tenuriostris* in Amazonia. A) Modeled habitat suitability prior to the record described herein. B) Change in suitability from (A), with the inclusion of our record in the modelling. Future scenarios: C) Change in suitability from A, modeled with minimum warming in the future (RCP 2.6, van Vuuren et al. 2011). D) Change in suitability from A, modeled with maximum warming (RCP 8.5, Riahi et al. 2011). The scale ranges from -100% (less suitable) change (blue) to +100% change (more suitable; red). Dotted line indicates the border of Amazonia.

Table 2. *Xenops tenuirostris* occurrence points used in the modelling. Wiki Aves (https://www.Wiki Avesaves.com.br/), Xeno-Canto-Canto (https://Xeno-Canto-canto.org/). Museum abbreviations: AMNH (American Museum of Natural History), ANSP (Academy of Natural Sciences of Drexel University), COP (Colección Ornitológica Phelps), CMNH (Cleveland Museum of Natural History), FMNH (Field Museum of Natural History), ICN (Universidad Nacional de Colombia's Instituto de Ciencias Naturales), LSUMNS (Museum of Natural Science, Louisiana State University), MPEG (Museu Paraense Emílio Goeldi), MZUSP (Museu de Zoologia da Universidade de São Paulo), USNM (National Museum of Natural History, Smithsonian Institution), LACM (Natural History Museum, Los Angeles County), RMNH (Naturalis Biodiversity Center), YPM (Peabody Museum of Natural History, Yale University.

Lattitude	Longitude	Source
-2.669238	-49.572998	This study
-3.465278	-64.984167	B. Whitney
-14.988809	-57.181138	Wiki Aves
-14.451469	-52.913078	Wiki Aves
-13.57688	-59.777474	Wiki Aves
-13.383244	-56.700275	Wiki Aves
-12.40861	-64.195602	Wiki Aves
-11.840611	-55.499732	Wiki Aves
-11.479157	-54.870415	Wiki Aves
-11.346839	-61.439516	Wiki Aves
-11.224203	-57.523228	Wiki Aves
-10.286682	-58.307454	Wiki Aves
-10.08175	-59.414406	Wiki Aves
-9.817115	-56.058049	Wiki Aves
-9.749342	-57.802387	Wiki Aves
-9.391115	-61.926833	Wiki Aves
-8.75373	-63.627603	Wiki Aves
-7.093302	-55.367414	Wiki Aves
-6.59953	-51.988466	Wiki Aves
-4.582488	-55.912822	Wiki Aves
-4.211352	-55.983822	Wiki Aves
-3.260922	-60.616563	Wiki Aves
-2.826855	-51.99492	Wiki Aves
-2.003902	-59.979178	Wiki Aves
-13.6838	-62.1194	Xeno-Canto
-13.5406	-56.6304	Xeno-Canto
-9.5981	-55.932	Xeno-Canto
-9.28	-55.8315	Xeno-Canto
-4.2889	-70.2948	Xeno-Canto
-2.0023	-59.8754	Xeno-Canto
-0.6742	-76.3978	Xeno-Canto
-0.641	-76.461	Xeno-Canto
4.2711	-52.3777	Xeno-Canto
-11.849937	-60.71717	AMNH Skin-127754, Skin-127755
-11.669496	-60.446307	AMNH Skin-127756
-0.62603	-77.432016	AMNH Skin-179442, Skin-179443, Skin-179444
5.666153	-53.781259	AMNH Skin-233881
4.929422	-52.329426	AMNH Skin-524474, Skin-524475, Skin-524476
5.881594	-55.121213	AMNH Skin-524477, Skin-524478
-13.520278	-69.629831	ANSP 103515
1.42941	-75.930382	ANSP 152643
4.916296	-52.336495	CNMH P57000, P60774, P60788
5.730185	-53.900184	CNMH P63408, P63457
4.127025	-51.669302	CNMH P65657, P65549, P65756, P65862
-4.267154	-55.993123	CNMH P77064
-3.349554	-55.349877	CNMH P77703, P78063
-7.680547	-65.764745	CNMH P87172, P87512
-5.783136	-63.63195	CNMH P93656, P93973
-3.288248	-60.601907	CNMH P99652
5.6	-67.5833	COP 20875
7.1667	-65.0833	COP 52899
-12.65	-70.333334	FMNH 251803
-12.830787	-71.250686	FMNH 315621, 315622, 315623, 321722
-9.755487	-61.855676	FMNH 330426
2.516707	-60.706933	FMNH 389200, 389201
-9.746746	-61.916399	FMNH 389827
1.13333333	-70.05	ICN 9752
1.5	-75.47	LACM 36414
-3.58	-72.75	LSUMNS 115142
-13.713203	-61.82886	LSUMNS 150700, 151879
-14.55	-60.92	LSUMNS 150701
-4.46666667	-78.16666667	LSUMNS 84746, 84747
-7.3333	-58.1572	LSUMNS B78507
-5.2803	-59.6958	LSUMNS B80520
-9.011	-59.431	LSUMNS B90151
-3.871017	-52.911781	MPEG 10871, 10872, 10873, 10874
0.58333333	-69.18333333	MPEG 17508, 17509
-9.73333333	-61.88333333	MPEG 39779
-4.46666667	-59.55	MPEG 53050
-3.41666667	-68.95	MPEG 55216
-6.18911111	-62.19013889	MPEG 73433
-7.71666667	-51.18333333	MZUSP 42347
2.521346	-60.698136	MZUSP 73339, 73340
-5.35	-57.13333333	MZUSP 84771
-7.352687	-58.153444	MZUSP 92720
5.797086	-55.470111	RMNH 120401
5.5083	-55.2083	RMNH 36221
3.344846	-55.436627	RMNH 38179
5.8417	-55.175	RMNH 53011, 27983
3.690704	-66.793673	USNM 329143
4.9333	-52.3333	YPM 29897
-7.6667	-65.7667	YPM 29898

that the generation length is 2.9 years; Remsen 2020). Because the arc of deforestation is predicted to have the greatest loss of forest area, the Slender-billed Xenops may lose much more habitat than predicted by climate change and so meet the criteria for Near Threatened (NT; IUCN 2021). We suggest that the Slender-billed Xenops receive more attention to better identify conservation and ecological issues, such as whether the species comprises one or many populations, and to examine how habitat quality and connectivity influence population persistence in an increasing fragmented landscape. All of these details will be required to determine, recommend, and implement future conservation efforts for the poorly known Slender-billed Xenops.

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