Herpetological Conservation and Biology 21(1):120–131.
Submitted: 22 July 2025; Accepted: 3 March 2026; Published: 30 April 2026.

The *Rhinella marina* Group in the Pampa Biome of South America: Spatiotemporal Records, Citizen Science, and Land Use/Cover Changes

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Abstract.—**The biodiversity crisis is outpacing conservation efforts, with amphibians among the most affected groups due to habitat loss, fragmentation, and disease. We analyzed spatiotemporal records of the *Rhinella marina* group, i.e., the Achaval's Toad (*R. achavali*), Argentine Toad (*R. arenarum*), Cururu Toad (*R. diptycha*), and Yellow Cururu Toad (*R. icterica*), in the South American Pampa biome. Locality data came from traditional sources (e.g., literature, institutional collections) and the citizen-science platform iNaturalist. We characterized the spatiotemporal distribution of the group, assessed the contribution of iNaturalist to occurrence data, and analyzed land use/cover changes around records. Between 2001–2020, records increased for all species except *R. icterica*, which were largely concentrated before 1980. iNaturalist contributed 48.5% and 39.2% of the grid cells defined for our spatiotemporal analysis of records for *R. arenarum* and *R. diptycha*, respectively, expanding coverage into areas poorly represented by traditional sources. Nevertheless, many areas still lacked recent records, indicating persistent temporal gaps in documentation. In our land-use analysis using 50-km buffered areas around species records, grassland cover declined for all species between 1985 and 2020, most strongly for *R. achavali* (from 68.5% grassland to 52.8%) and *R. icterica* (from 43.2% to 28.2%), coinciding with marked expansion of agriculture or pasture over the same period, especially for *R. icterica* (from 27.8% agriculture/pasture to 37.1%) and *R. achavali* (from 12.8% to 20.3%). Overall, sampling gaps combined with habitat loss may mask local declines. Systematic surveys integrating traditional and citizen science are essential to better assess population trends and threats in the Pampa biome.**

Key Words.—agriculture; amphibians; biodiversity conservation; habitat loss

Introduction

Global biodiversity is experiencing population declines at a rate approaching that of the last five mass extinctions (Dirzo et al. 2014; Ceballos et al. 2015). One of the main causes is habitat loss and fragmentation, which occur through the conversion of natural habitats into agriculture, forest plantation, and urbanization (Hanski 2005). Land use/cover change reduces environmental complexity, removing essential requirements for many species (Serrano et al. 2023). Urbanization, for example, alters habitat structure and complexity, which are crucial for the survival of many species (Gardner et al. 2007). Moreover, the anthropogenic barriers created by these changes weaken connectivity between metacommunities, preventing the movement of individuals (Hamer and McDonnell 2008). Additionally, the expansion of agriculture and forest plantations, particularly in Brazil and Uruguay, has intensified the use of synthetic chemicals, leading to losses in organismal richness such as those observed in amphibians (Brazeiro et al. 2008; Hamer and McDonnell 2008).

Amphibians are considered the most threatened group of vertebrates worldwide, with an estimated 40.7% of species at risk (Deutsch et al. 2023; Luedtke et al. 2023). This group has been experiencing population declines in the number of individuals within populations, the number of populations within regions, and reductions in distribution (Campbell Grant et al. 2020). Despite significant knowledge of the main causes behind many declines, the most recent global assessment (based on 2022 data) indicates that 48% of cases are considered enigmatic (Luedtke et al. 2023), meaning they have no specifically defined cause. Additionally, although some species are not classified as at risk, anurans are organisms that can experience sudden declines due to physiological factors that make them highly sensitive to environmental changes (Cunha et al. 2015). According to the International Union for Conservation of Nature (IUCN), previous assessments have underestimated amphibian population declines, leading to a considerable number of species not being classified as threatened due to a lack of data (Toledo et al. 2023). Recent studies, such as those conducted in the Atlantic Forest biome of South America, show significant population declines in anurans (Toledo et al. 2023), particularly among species of the genera *Megaelosia*, *Phantasmarana*, and *Ceratophrys* (Augusto-Alves et al. 2023).

In the Pampa biome, several amphibians have experienced severe declines, highlighting the critical conservation status of the region. The Argentine Horned Frog (*Ceratophrys ornata*) has not been recorded in the Pampa since the 1980s, even within protected areas such as Taim Ecological Station (Maneyro et al. 2017; Tozetti et al. 2023), and other species such as the Montevideo Redbelly Toad (*Melanophryniscus montevidensis*) and Red-spotted Argentina Frog (*Argenteohyla siemersi*) have also disappeared from many historical localities in Uruguay, Brazil, and Argentina, suggesting regional declines or possible local extinctions (Maneyro and Carreira 2012; Agnolin and Guerrero 2017; Deutsch et al. 2018). The Pampa remains one of the least protected and studied biomes in Brazil, with only about 3% legally protected and few amphibian surveys, limiting the detection of declines (Severo and Matte 2020; Deutsch et al. 2017; Augusto-Alves et al. 2023). Land-use conversion to agriculture and forestry has reduced biodiversity and soil fauna (Góes et al. 2021), likely affecting amphibians. Declining records of the Argentine Toad (*Rhinella arenarum*) in agricultural areas exposed to agrochemicals (Bionda et al. 2012, 2013), and the ecological similarity among *R. marina* group species (Pereyra et al. 2021) suggest that other congeners may also be experiencing similar pressures and undetected local declines (Maneyro et al. 2017; Luedtke et al. 2023). Despite their relative abundance and ecological tolerance, these species often persist in disturbed and urbanized areas (Schuman et al. 2023; Mackenzie and Vladimirova 2022). As tolerant generalists typically persist in modified habitats, declines in these species may instead reflect stronger underlying environmental pressures (Nowakowski et al. 2017).

Population monitoring has become an important tool for assessing ecosystem health and guiding conservation (Brodeur and Condioti 2017). Understanding species distribution is essential for interpreting current patterns and developing conservation strategies (Serrano et al. 2023), while regular assessments help detect population fluctuations (Luedtke et al. 2023). The increasing availability of digital records from museums and collections has improved knowledge of distribution ranges and temporal trends (Serrano et al. 2023; Gaul et al. 2020; Augusto-Alves 2023; Toledo et al. 2023). Lack of records in these datasets, however, may reflect insufficient sampling rather than true species absence in an area (Di Cecco et al. 2021; Serrano et al. 2023). Citizen science platforms, such as iNaturalist, can complement these sources by generating large volumes of biodiversity data across wide spatial and temporal scales, thereby enhancing our ability to detect patterns and support conservation (Hart et al. 2012; Di Cecco et al. 2021). Therefore, given the global collapse of anuran species and the extensive loss of natural areas within the Pampa biome, this study aims to: (1) assess the spatiotemporal distribution patterns of the four species within the *R. marina* group in the Pampa biome by integrating data from traditional sources and the citizen science platform iNaturalist; (2) evaluate the contribution of iNaturalist to species record quantity and spatial distribution coverage; and (3) document land use and cover changes in areas surrounding occurrence records within the Pampa biome.

Materials and Methods

Data collection.—We focused our data collection on the spatiotemporal records of individuals the Achaval's Toad (*Rhinella achavali*), Argentine Toad (*R. arenarum*), Cururu Toad (*R. diptych*), and Yellow Cururu Toad (*R. icterica*), including both tadpoles and post-metamorphic stages, within the Pampa biome (Fig. 1). During our searches, we adopted the nomenclature previously assigned to each species. We retrieved scientific articles and dissertations through targeted searches conducted on the Web of Science (https://www.webofscience.com; last accessed 16 August 2024) and Scopus (https://www.scopus.com; last accessed 16 August 2024) platforms (see Supplemental Information Table S1). In addition, we gathered data from specimens housed in scientific collections, available in digital databases such as the Global Biodiversity Information Facility (GBIF; https://www.gbif.org) and SpeciesLink (https://specieslink.net, last accessed 26 April 2024; Augusto-Alves et al. 2023; Toledo et al. 2023). To complement these records, we assessed records from

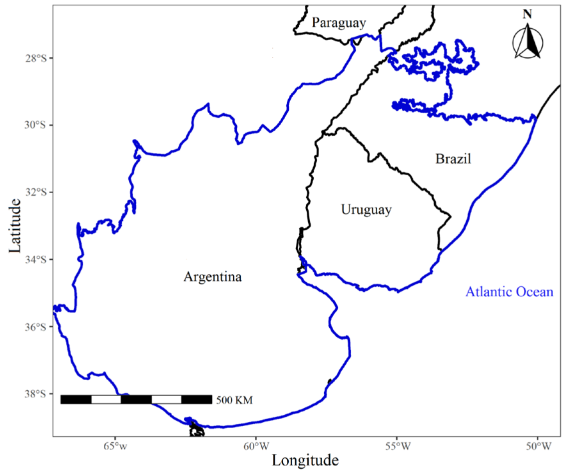

Figure 1. Location of the Pampa biome (blue outline) in South America. Country borders (black lines) highlight the Pampa distribution across southern Brazil, Uruguay, and northeastern Argentina. The biome was delimited according to the MapBiomas Pampa project (Projeto MapBiomas 2024).

the herpetology collections of the Federal University of Santa Maria (UFSM, Brazil), the Federal University of Rio Grande do Sul (UFRGS, Brazil), the Federal University of Rio Grande (FURG, Brazil), and the Universidad de la República (UdelaR, Uruguay).

We also specifically assessed the contribution of records from the iNaturalist, with data retrieved via the GBIF platform, where they are updated on a weekly basis. We used iNaturalist records with photographic or audio evidence and community-verified identifications (Research Grade), thereby increasing reliability in species determination (iNaturalist. 2024. What is Research Grade? iNaturalist. Available from https://www.inaturalist.org/pages/help#quality). Furthermore, we manually checked all photographs to confirm that identifications matched known diagnostic traits (Maneyro and Carreira 2012; Maneyro et al. 2017). We included only records from Argentina, Uruguay, and the state of Rio Grande do Sul in Brazil, thereby encompassing the distribution range of the studied species within the Pampa biome.

We refined our dataset to include only records located within the Pampa biome. To do this, we retained only those records that provided both the year and a collection location (defined at least to the municipality level, based on boundaries set by the Brazilian Institute of Geography and Statistics [IBGE]) and then filtered the data using the Pampa biome limits defined by the MapBiomas Pampa project (Projeto MapBiomas 2024). Our final dataset comprised all records collected up to 2020.

Data analysis.—We carefully reviewed the dataset to identify and eliminate duplicate records across sources. This included potential overlaps between university collections provided directly to us and records already incorporated into GBIF or SpeciesLink. We treated records from the same locality as independent entries in the dataset, as each represents a separate observation. Additionally, we excluded one record each of *R. diptycha* and *R. icterica* that were located far outside their known distribution ranges, as determined by visual inspection of their mapped occurrences. We carried out all stages of data analysis using R 4.4.2 (R Core Team 2024) and Quantum Geographic Information System (QGIS Development Team, Open Source Geospatial Foundation, Beaverton, Oregon, USA; QGIS Development Team 2024). We used the final filtered dataset, which comprised both traditional sources and citizen science data (iNaturalist). Traditional sources included scientific articles, dissertations, scientific collection specimens, and records from GBIF and SpeciesLink (excluding iNaturalist records accessed via GBIF).

We used this dataset to generate summary statistics, map the distribution of records across time periods, and evaluate temporal and spatial patterns of occurrence and associated land use/cover changes. We divided data into four time periods: 2001–2020, 1981–2000, 1961–1980, and before 1960. All records were assigned to 0.5° latitude/longitude grid cells using the sf package functions st_make_grid() and st_join() (Pebesma 2024) to support spatiotemporal analyses and comparisons between iNaturalist and traditional data sources.

For the spatiotemporal analysis, we determined, for each species and each grid cell, the most recent time period sampled using the slice_max() function from the dplyr package (Wickham et al. 2023b). These time frames allowed us to map temporal patterns of species records and to assess when each species was last recorded in specific areas (Serrano et al. 2023). To quantify the contribution of citizen science in expanding spatial coverage and increasing record quantity, we categorized for each species and each grid cell, whether the cell contained records only from traditional sources (collections, catalogues, articles, etc.), only from the iNaturalist platform, or from both sources, using the summarise() function of dplyr. We then plotted the resulting grids for each species.

To quantify changes in land use/cover around species records, we created 50-km buffers around occurrence points and dissolved overlapping buffers before extracting land-use data in QGIS. We then extracted data for the following land use/cover categories from datasets for the years 1985 and 2020: forest formation, savanna formation, forest plantation, wetland, grassland, agriculture or pasture, non-vegetated area, and river, lake and ocean. We obtained this data from the MapBiomas Pampa platform (https://pampa.mapbiomas.org/pt/home-3/) and processed it using QGIS. We applied the OpenLand (Exavier and Zeilhofer 2020) and tidyverse (Wickham et al. 2023a) packages to calculate changes and generate graphs that illustrate shifts in land use/cover classes. For these analyses, we reprojected all data to the Equal Area Scalable Earth Grids, a Global Cylindrical Equal-Area Projection (EPSG: 6933) (Brodzik et al. 2002) and resampled the MapBiomas data to 30-m resolution.

Results

Data collected.—The search on the Web of Science and Scopus platforms initially yielded a large number of records; however, many articles did not report the year or location of data collection, rendering them invalid for analysis. After filtering the 1,463 articles found in Scopus, only 57 contained records with collection year and location. Among these, we found articles for *R. arenarum* (54), *R. icterica* (two), and *R. achavali* (one), while *R. diptycha* had no eligible records. In Web of Science, out of the initial 1,367 articles, only 76 met the inclusion criteria. *Rhinella arenarum* was once again the most represented species (42 articles), followed by *R. diptycha* (seven), *R. icterica* (four), and *R. achavali* (one). Additionally, we identified 22 articles with species records through targeted searches for studies reporting inventories, species lists, or assemblages of anurans in the Pampa biome.

By integrating records from the GBIF and SpeciesLink databases, along with data from scientific collections, analyzed articles, and citizen science observations from iNaturalist, we obtained an initial total of 8,920 records, representing the full dataset (see Supplemental Information Table S2). After filtering to include only records within the boundaries of the Pampa biome, however, this number was reduced to 4,893 records. Of these, the most recorded species was *R. arenarum* (4,402 records), followed by *R. diptycha* (348), *R. icterica* (80), and *R. achavali* (63).

Temporal and spatial distribution of records.—For three of the species (*R. achavali*, *R. arenarum*, *R. diptycha*), the number of records increased substantially in the most recent time period (2001–2020; Fig 2). In contrast, *R. icterica* had the highest number of records between 1961–1980, followed by a progressive decline in subsequent periods. The temporal and spatial distribution of the most recent records (Fig. 3) highlights inconsistencies in records across regions among time periods. While old records (prior to 1960) were restricted to relatively few localities, more recent records (2001–2020) encompass a broader geographic range compared to earlier periods. For three of the four species the most recent record for each locality over time within the recorded areas showed the highest concentration in the latest time period (2001–2020; Fig. 3). Within this interval, 77.7% of *R. achavali* grid cells, 84.4% of *R. arenarum*, and 94.5% of *R. diptycha* were most recently documented during 2001–2020. In contrast, *R. icterica* had 66.6% of its locations last recorded before 2000, and only 33.4% last recorded after 2000.

iNaturalist records.—The analysis of iNaturalist contributions to total records showed that they were substantially fewer than those from traditional sources, such as scientific articles and institutional databases (Fig. 2). Nevertheless, the proportional contribution of iNaturalist was substantially greater in the 2001–2020 interval, corresponding to the period during which the platform was active. Across the full dataset, the proportion of iNaturalist records relative to total observations varied among species: 10.6% (n = 469) for *R. arenarum,* 24.7% (n = 86) for *R. diptycha,* 3.7% (n = 3) for *R. icterica,* and 1.5% (n = 1) for *R. achavali* (Fig. 2).

Although iNaturalist contributed a smaller share of the total number of records, it substantially increased the number of grid cells documented exclusively by this platform, especially for *R. arenarum* and *R. diptycha* (Fig. 4). The iNaturalist records for these two species were more widely distributed and often located in areas not represented by traditional sources, enhancing the overall geographic coverage. Specifically, iNaturalist accounted for 48.5% of the grid cells derived exclusively from this platform **for** *R. arenarum* (n = 50) and 39.2% for *R. diptycha* (n = 22), highlighting its substantial role in expanding spatial coverage and complementing traditional datasets. In contrast, *R. achavali* and *R. icterica* had very limited exclusive contributions from iNaturalist, with only 5.5% of grid cells (n = 1 for each) coming

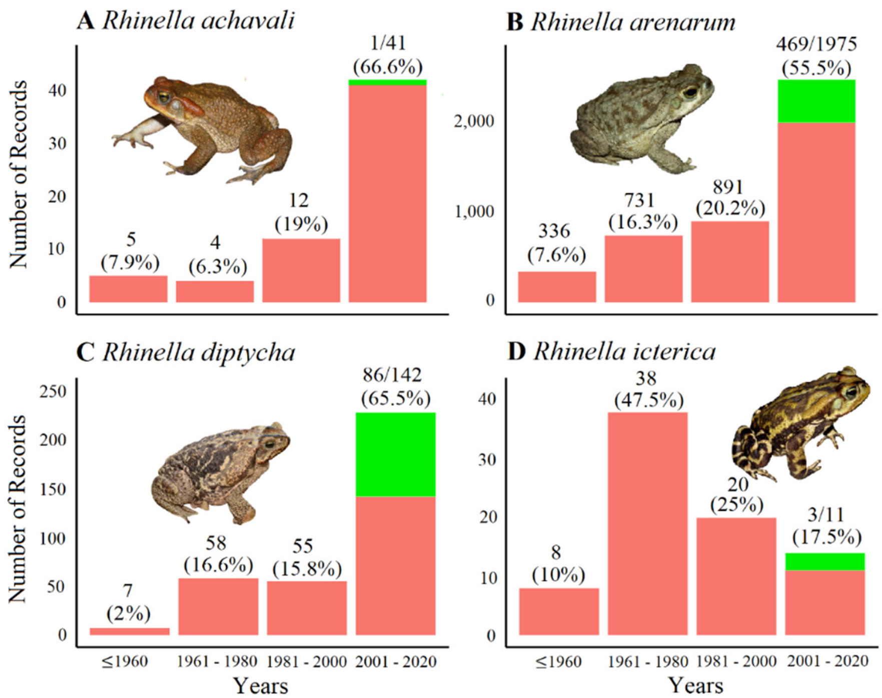

Figure 2. Number of individual records from traditional sources (red bars) and iNaturalist (green bars) for four *Rhinella* species in the Pampa biome in South America across different time periods: (A) Achaval's Toad (*Rhinella achavali*), (B) Argentine Toad (*Rhinella arenarum*), (C) Cururu Toad (*Rhinella diptycha*), and (D) Yellow Cururu Toad (*Rhinella icterica*). The numbers above each bar indicate the counts from iNaturalist records followed by traditional sources (e.g., 1/41); when there is no second number, the number indicates that only traditional records were available for that time period. Numbers in parentheses represent the percentage of the total records for each species within that time period. (Photographs of toads by Daniel Loebmann).

solely from this source, as most occupied cells were documented by traditional sources or by both datasets combined (Supplemental Information Table S3).

Land use/land cover change.—Land use and cover changes between 1985 and 2020 within the 50-km buffered areas around the records of the four *Rhinella* species revealed a consistent pattern of substantial loss of natural grassland for all four species (Fig. 5). This reduction was accompanied by a marked increase in agriculture or pasture and forest plantations, indicating a clear expansion of anthropogenic land use into natural landscapes. Among species, *R. achavali* and *R. icterica* exhibited the greatest declines in the proportion of grassland cover, decreasing from 68.5% to 52.8% and from 43.2% to 28.2%, respectively. *Rhinella diptycha* and *R. arenarum* also showed notable reductions, with grassland cover decreasing from 50.2% to 41.4% and from 28.9% to 23.4%, respectively. Conversely, areas classified as agriculture or pasture increased in their proportional representation, particularly for *R. icterica* (from 27.8% to 37.1%) and *R. achavali* (from 12.8% to 20.3%). *Rhinella diptycha* and *R. arenarum* also showed increases in agriculture or pasture, from 22.8% to 27.7% and from 47.8% to 51.6%, respectively.

Forest plantations expanded in their proportional representation across all species, most notably for *R. achavali* (from 0.5% to 7.9%) and *R. icterica* (from 0.8% to 6.0%). Wetland areas remained relatively stable, showing only minimal fluctuations. Values ranged from 2.4% to 2.3% for *R. achavali*, 8.2% to 8.1% for *R. arenarum*, 7.8% to 8.2% for *R. diptycha*, and 2.6% to 2.7% for *R. icterica*. A slight increase in savanna formations was detected for *R. arenarum*, whereas *R. diptycha* and *R. icterica* showed small decreases (Supplemental Information Table S4).

Discussion

Sampling gaps and conservation challenges.—The temporal and spatial analysis of records for the four *Rhinella* species revealed uneven sampling through time, with *R. achavali*, *R. arenarum*, and *R. diptycha* showing a clear increase in records after 2001, whereas *R. icterica* had most records concentrated between 1961 and 1980. This pattern may be related to the ecological characteristics of

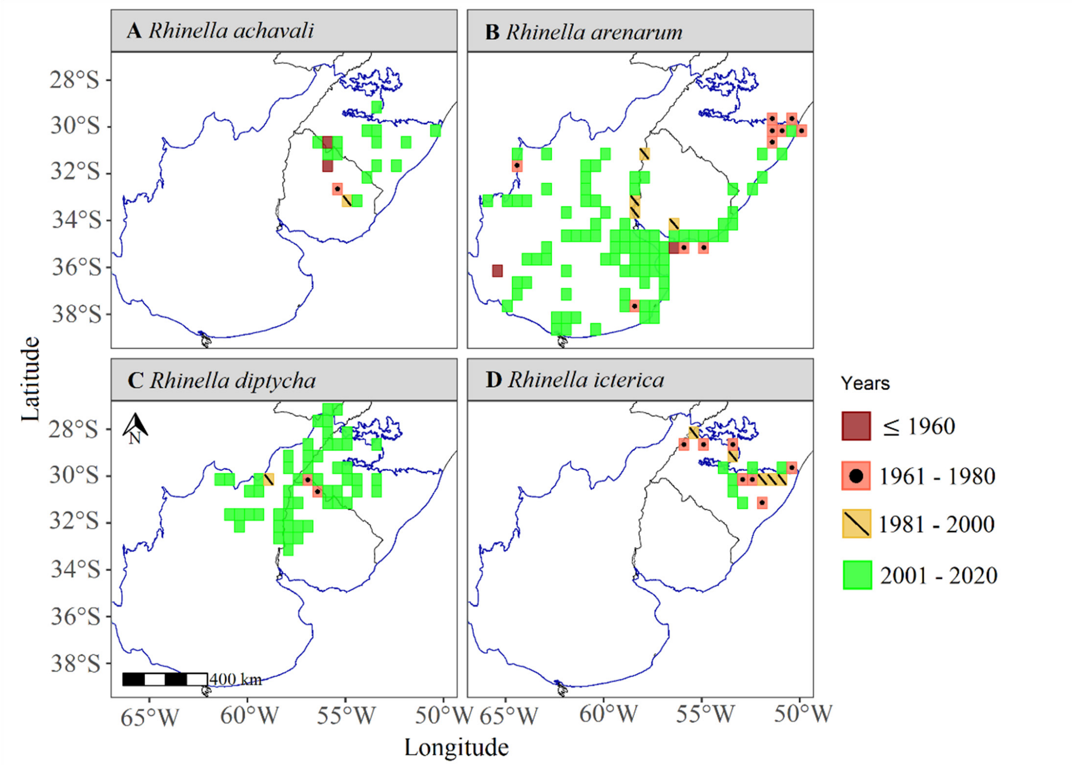

Figure 3. Spatial and temporal distribution of the latest unique locality records in 0.5° grid cells from traditional and iNaturalist sources combined for *Rhinella* species in the Pampa biome of South America. Species are (A) Achaval's Toad (*Rhinella achavali*), (B) Argentine Toad (*Rhinella arenarum*), (C) Cururu Toad (*Rhinella diptycha*), and (D) Yellow Cururu Toad (*Rhinella icterica*). The blue outline represents the boundaries of the Pampa biome, while the thin black lines indicate country boundaries.

R. icterica, a species that, although not exclusive to forested environments, is commonly found in humid and preserved areas of the Atlantic Forest biome, often at higher elevations and near watercourses (Pereyra et al. 2021). Despite efforts to preserve the Atlantic Forest, studies indicate that since the 1980s, the loss of mature forest cover has ranged between 220,000 and 80,000 ha/y, accompanied by the fragmentation of up to 36% of these areas (Rosa et al. 2021). Other amphibians in the Atlantic Forest have experienced sharp declines throughout the 20th Century, which have been linked to habitat loss and fragmentation, as well as emerging diseases (Scheele et al. 2019; Augusto-Alves et al. 2023; Toledo et al. 2023). Thus, the decline in *R. icterica* records, which were all in the transition zone between the Atlantic Forest and the Pampa, may be related to these environmental changes (Gibson et al. 2011).

Beyond the decline in *R. icterica* records in the transition between biomes, other concerning patterns emerge in the distribution of *R. marina* group species in the Pampa. The percentage distribution of unique records from all sources shows that 22.2% of the sampled areas for *R. achavali*, 15.5% for *R. arenarum*, and 5.4% for *R. diptycha* have had no new records for 20 y or more. These gaps may result from uneven sampling over the decades, influencing inferences about biogeographic patterns and conservation (Botts et al. 2011). In many cases, species are detected only within or near protected areas, creating a sampling bias, as research is often conducted in these regions while other areas remain under-sampled (Serrano et al. 2023).

This limitation in data availability gains additional importance when considered under the purview of IUCN Criterion B, which is widely used to assess the extinction risk of amphibians in the absence of robust population data (Stuart et al. 2004). Criterion B primarily takes into account extent of occurrence (EOO), area of occupancy (AOO), habitat fragmentation, ongoing population decline, and extreme fluctuations, using both historical and current records to delineate species distributions (Collen et al. 2016). The misleading use of historical records, however, such as assuming that older occurrence points still represent current populations,

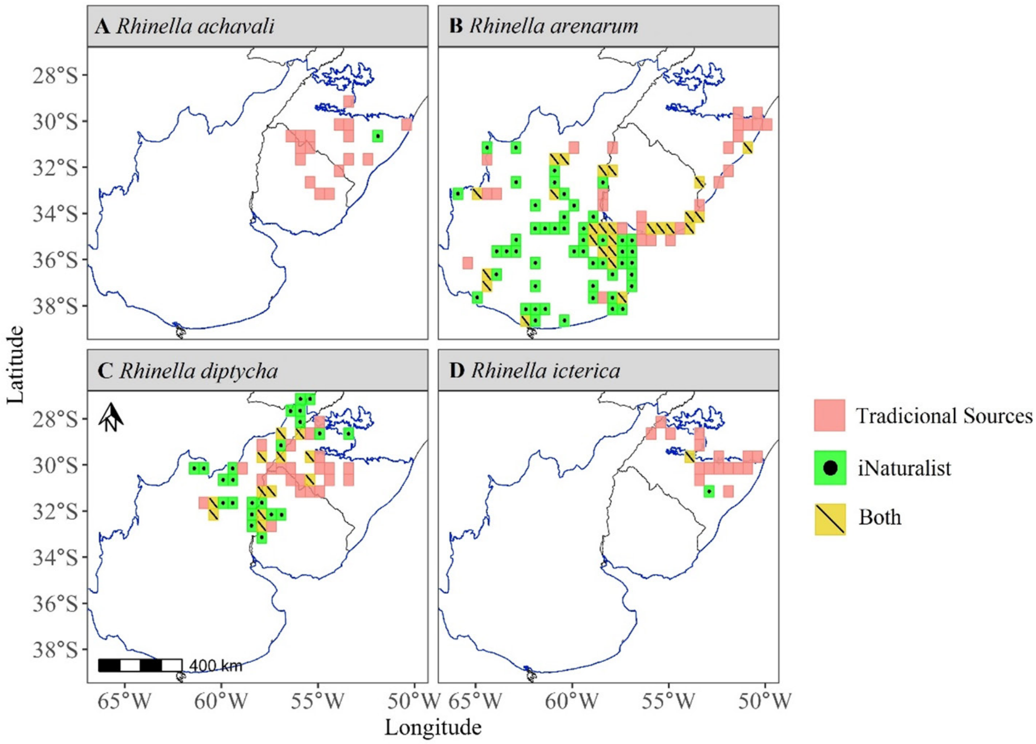

Figure 4. Spatial distribution of records by 0.5° grid cells for the species (A) Achaval's Toad (*Rhinella achavali*), (B) Argentine Toad (*Rhinella arenarum*), (C) Cururu Toad (*Rhinella diptycha*), and (D) Yellow Cururu Toad (*Rhinella icterica*). The Pampa biome is outlined in blue, and country borders are shown as thin black lines.

can lead to overestimation of the present distributions of species, hindering accurate assessments. Serrano et al. (2023) and Collen et al. (2016) emphasize that older data, particularly from highly altered regions, may no longer reflect the actual presence of species due to habitat degradation and fragmentation, masking population declines and resulting in an underestimation of the true extinction risk.

The species analyzed in our study are currently classified as Least Concern (LC) in the IUCN database (IUCN 2023), suggesting that they are not facing imminent extinction risks. Although the total number of records has increased over time, the spatial data revealed that many localities still lack recent observations, indicating gaps in recent sampling efforts. A similar pattern was reported by Augusto-Alves et al. (2023), who found that at least 40 populations of the Brazilian Horned Frog (*Ceratophrys aurita*), also classified as LC by the IUCN, have not been recorded since 1990. This highlights the potential for undetected population declines even in seemingly stable species. Therefore, the absence of records in certain regions, even for species classified as LC by the IUCN, such as those analyzed in this study, does not rule out the possibility of localized population declines. Given this, implementing more detailed assessments, particularly the resampling of historical sites, and continuous spatial monitoring programs is essential to better understand the actual distribution and conservation status of these and other species in the Pampa biome (Tingley and Beissinger 2009).

Growth and limitations of citizen science in species recording.—iNaturalist contributed unevenly to species records, with *R. arenarum* showing the highest proportion of grid cells derived exclusively from this platform (48.5%; Supplemental Information Table S3). This predominance likely reflects its wide distribution and ecological tolerance, as the species occupies diverse habitats, including urban areas (Pollo et al. 2025). Additionally, iNaturalist data substantially expanded the number of grid cells recorded exclusively by this platform for *R. diptycha* (39.2%; Supplemental Information Table S3), underscoring the value of citizen science in improving distribution knowledge. Similar trends were observed by Deutsch et al. (2017) for *Ceratophrys ornata*, where citizen-science records significantly enhanced range information and conservation insights.

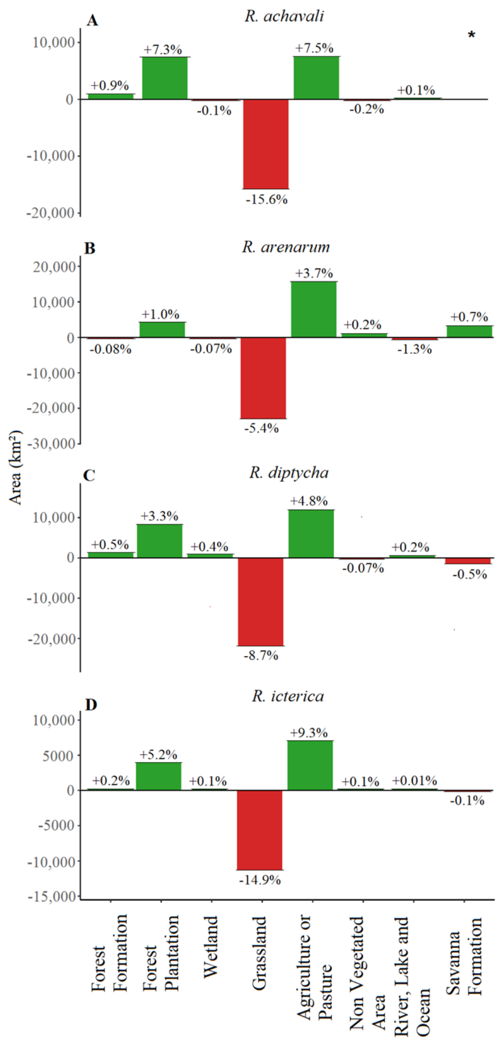

Figure 5. Land use/cover changes for a 50-km buffer around records of four *Rhinella* species in the Pampa biome of South America. The Y axis represents change in area (km2) of land use/cover categories (X axis) between 1985 and 2020 for (A) Achaval's Toad (*Rhinella achavali*), (B) Argentine Toad (*Rhinella arenarum*), (C) Cururu Toad (*Rhinella diptycha*), and (D) Yellow Cururu Toad (*Rhinella icterica*). Green bars represent net gain in a specific land use/cover, and red bars indicate net loss. Asterisks (*) indicates that savanna does not occur within the buffered areas around records of *R. achavali*. Percentage values represent the relative proportional change in land-use/cover between 1985 and 2020 within the buffered areas

By contrast, citizen-science data showed clear limitations for some species. For *R. achavali* and *R. icterica*, iNaturalist accounted for only 5.5% of the grid cells recorded *solely* by this platform (n = 1 for each species), whereas the vast majority of grid cells were documented either by traditional sources or by both datasets combined (Supplemental Information Table S3). These two species have the smallest distribution ranges among those analyzed, which may explain their greater representation in traditional datasets and the low detection of unique localities in iNaturalist. Further studies are needed to confirm whether this pattern reflects ecological traits or sampling bias, as citizen-science data are known to exhibit spatial and taxonomic biases related to observer behavior, accessibility, and species visibility (Callaghan et al. 2021). Moreover, citizen-generated data are inherently presence-only, collected opportunistically, and concentrated in more accessible or densely populated regions (Tulloch et al. 2013b; Chandler et al. 2017a), resulting in uneven spatial coverage. Although these structural biases limit data completeness, valuable insights can still be gained by accounting for survey effort or contrasting detections of other species (Callaghan et al. 2021). Similar limitations affect traditional scientific surveys, which are constrained by financial, logistical, and access barriers (Callaghan et al. 2021). Therefore, integrating public participation and structured monitoring is essential to expand spatial coverage, reduce sampling gaps, and enhance the representativeness of biodiversity records.

Habitat loss and alterations.—Across the Pampa biome, land-use dynamics within the distributional ranges of *Rhinella* species reveal a clear trend of grassland decline, accompanied by the expansion of agriculture or pasture and forest plantations. These transformations reflect the intensification of human activities in southern South America (Paruelo et al. 2022; Severo and Matte 2020), now documented quantitatively for the habitats occupied by the *Rhinella marina* group. Among species, *R. achavali* and *R. icterica* experienced the most pronounced proportional losses of grassland cover, accompanied by marked increases in agriculture or pasture and forest plantations.

Although species of *Rhinella* display ecological tolerance and are frequently observed in modified landscapes, the progressive replacement of natural grasslands can disrupt connectivity among suitable habitats and reduce environmental heterogeneity. Such fragmentation may limit dispersal, isolate breeding sites, and increase exposure to anthropogenic stressors, ultimately reducing population resilience (Serrano et al. 2023). Even for tolerant species, the persistence of native grassland remnants likely remains essential for maintaining viable metapopulations and functional ecological networks.

Beyond vegetation loss, the spread of monocultures (included in agriculture or pasture) and forest plantations introduces additional stressors that modify hydrological and soil conditions critical to anuran life cycles. The replacement of native vegetation by eucalyptus and other exotic species alters water retention, soil pH, and nutrient dynamics, indirectly affecting nearby wetlands (Baeza et al. 2022; Babini et al. 2024). Although total wetland area remained relatively stable (all species showing < 1% variation), these environments are increasingly embedded within intensively managed landscapes, where runoff from fertilizers and pesticides can accelerate larval development and reduce reproductive success (Bionda et al. 2012, 2013).

Altogether, these patterns reinforce the importance of integrating land-use planning and habitat management within amphibian conservation strategies. Maintaining mosaics that combine natural grasslands, wetlands, and low-intensity agricultural systems may help preserve connectivity and buffer populations of *Rhinella* species against the ongoing homogenization of the Pampa landscape.

Conclusions.—Our study provides an integrated overview of the distribution, data sources, and habitat context of four species from the *Rhinella marina* group in the Pampa biome. By combining traditional datasets and iNaturalist records, we documented a broader and more detailed picture of the occurrence patterns of these species. Citizen-science data, from iNaturalist, played a valuable role in complementing traditional datasets by revealing new localities and enhancing the understanding of species distributions across the Pampa biome. These findings emphasize the complementary importance of citizen-generated information in mapping amphibian diversity and supporting future conservation and monitoring efforts in underrepresented regions.

Analyses of land-use change within the ranges of the species group revealed a decline in natural grasslands and expansion of agriculture and forest plantations. Although *Rhinella* species are ecologically tolerant and capable of persisting in modified landscapes, ongoing habitat conversion may reduce ecological connectivity and the availability of suitable breeding sites. At the same time, large areas of the Pampa remain poorly sampled, highlighting the need to strengthen monitoring coverage and integrate habitat management with biodiversity surveys to refine species distribution knowledge and preserve both population persistence and the ecological integrity of the biome. Together, these findings establish a robust baseline for future investigations by highlighting where knowledge gaps remain and how citizen participation can bridge them. Strengthening the link between traditional research, citizen-science initiatives, and local community engagement will be crucial for building long-term, spatially comprehensive monitoring frameworks that support amphibian conservation in southern South America

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Acknowledgments.—We thank Jeferson Arruda (technician at the Federal University of Santa Maria - UFSM, Herpetology Laboratory) and Tiago Gomes (Federal University of Pampa - Unipampa) for their support in obtaining data from the UFSM herpetology collection. We also extend our gratitude to Raul Maneyro for providing herpetological data from the scientific collection of the Universidad de la República - Udelar, and to Márcio Borges-Martins for making data available from the herpetology collection of the Federal University of Rio Grande do Sul. JAPC acknowledges support from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES; grant # 88887.959036/2024-00). DL is a researcher supported by the National Council for Scientific and Technological Development, Brazil (grant # 307232/2023–9).

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Supplemental Information: http://www.herpconbio.org/Volume_21/Issue_1/Caseiro-Silva_etal_2026_Suppl.pdf

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