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OXFORD

Original Article

Amphibian sound recordings in Brazil are geographically and taxonomically biased and cover less than two-thirds of native species

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ABSTRACT

Recordings of animal vocalizations are useful for behavioural, ecological, and taxonomic studies. Herein, we provide an overview of 15 sound collections in Brazilian institutions housing recordings of amphibian calls. For each collection, we assessed the number of recordings and species with audio files deposited. Based on the 25385 recordings, we provide a list of species, highlighting 26 species with undescribed calls. Hylidae (~48%) and Leptodactylidae (~21%) were the two most representative families, probably due to the high number of species described for these

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families. The number of recordings was not related to the age of the collections. We presume that there are some idiosyncratic features of these collections affecting these numbers, such as the collaborators' network range and the public system for data input, that are more relevant than the collection age. Body size and geographical range size were strong predictors of the number of recordings available. Interestingly, closely related species had a similar number of recordings in the collections, suggesting a phylogenetic bias in sampling effort. More than 30% of native species are not represented in sound collections. Therefore, we emphasize the need for the creation of new bioacoustics collections, especially with more social engagement to obtain new records in currently underrepresented regions.

Keywords: Anura; bioacoustics; frog calls; natural history collections; sound archives

INTRODUCTION

Mitigating anthropogenic impacts (e.g. habitat loss, climate change, and pollution) on the environment represents one of the great challenges of the 21st century. Adequate conservation and participatory management strategies must be urgently implemented to minimize impacts on biodiversity (Watson *et al.* 2016, Baldauf 2020, Cross *et al.* 2021). However, information related to the geographical distribution, natural history, and taxonomy of organisms remains fundamental to the effectiveness of these strategies (Hortal *et al.* 2015). In this context, natural history collections are essential sources of data on biodiversity, since they house a variety of biological information collected over time and space for various taxa (Meineke *et al.* 2018). Therefore, these collections can support ecological, evolutionary, taxonomic, and conservation studies and, consequently, contribute to the elaboration of effective conservation and management strategies (Meineke *et al.* 2018).

Available data in natural history collections include those that can be obtained directly from preserved specimens and also indirectly, such as parasites, blood and tissue samples, environmental data, besides extended specimens which include photos, audio, and video recordings (Webster 2017, Gropp 2018, Mendoza-Henao *et al.* 2021). Audio recordings are particularly interesting, as they provide data on behaviour and for several animal groups can be used to study sexual selection and species recognition (Ryan *et al.* 1990, Toledo *et al.* 2015, Zhao *et al.* 2017). In addition, compared to physical specimens, sound files are relatively easy to obtain and their storage and curation have a low cost (Toledo *et al.* 2015). However, despite their importance and advantages, sound collections have received little attention compared to specimen and DNA collections (Toledo *et al.* 2015, Mendoza-Hernao *et al.* 2021).

Representation of different taxa in natural history collections is notoriously unbalanced, and amphibians usually have many fewer records than birds (iDigBio 2022, GBIF 2022). However, amphibians are the most threatened vertebrates on earth (Luedtke *et al.* 2023, IUCN 2025), and data on this group are pivotal for biodiversity protection (Shaffer *et al.* 1998). Amphibian population declines have been recorded for several species around the world (Wake and Koo 2018) and currently approximately 40% of species are threatened with extinction (Luedtke *et al.* 2023). In anurans, acoustic communication plays a crucial role in mediating several components of life history (Wells 2007). Over the past decades, anuran calls have been increasingly studied and this research has provided substantial ecological, evolutionary, behavioural, and taxonomic knowledge (e.g. Köhler *et al.* 2017, Brasileiro *et al.* 2020, 2021). As a result, acoustic data have been collected for several species, which is not necessarily reflected in the number of audio files deposited in sound collections (Köhler *et al.* 2017, Guerra *et al.* 2018, Rivera-Correa *et al.* 2021). However, for many regions of the world, little is known about the audio recordings stored in sound collections and only a few studies have focused on this topic (Köhler *et al.* 2017, Dena *et al.* 2020, Mendoza-Henao *et al.* 2021). For instance, Köhler *et al.* (2017) provided definitions and technical standards based on audio recordings of anuran species deposited in sound collections around the world. Assessing species and the associated metadata through sound collections represents an important way to find new directions through which to reduce knowledge gaps and guide future research in bioacoustics. At the same time, this kind of analysis can identify available materials for future research, such as species that lack formal descriptions of their calls.

With over 1250 species, Brazil has the richest amphibian diversity in the world (Frost 2025). The number of bioacoustics studies has increased considerably over the last few decades, covering vocal repertoires, acoustic variability (within-individual, between-individual, and among-population levels), playback experiments, and passive acoustic monitoring (Bastos *et al.* 2021). Nevertheless, for many species even basic information is lacking with regard to natural history, since few species have their acoustic repertoire well documented and even fewer have had experimental bioacoustic studies conducted on them (Guerra *et al.* 2018, Bastos *et al.* 2021). Nevertheless, how these studies have contributed to sound collections in Brazil is unknown. Köhler *et al.* (2017), Guerra *et al.* (2018), and Mendoza-Henao *et al.* (2021) have provided data on some Brazilian acoustic collections, but many gaps still remain. For example, we still do not know how many acoustic collections contain anuran vocalizations in Brazil and where they are located. We also need information on which taxa are most represented and which are missing. Furthermore, nearly 80% of Brazilian herpetologists do not deposit sound recordings from field expeditions, resulting in the loss of important biological information (Dena *et al.* 2020). This lack of data shows that acoustic collection is a neglected research topic in Brazil.

Herein, we provide an overview of the anuran audio recordings housed in sound collections at Brazilian research institutions, and we also include a quantitative and qualitative description of the datasets in these collections. Expecting to find spatial, ecological, and taxonomic biases, we hypothesized that the number of recordings would be sensitive to the geographical range and species body size and phylogeny, as well as the time since the species was first described. We presume that common and large species are often easier to detect than those that are rare and small. Some anuran lineages are probably better studied than others because systematists often have specific taxonomic targets. We also assume that a species with a longer time since its description will have accumulated more observations over time. Based on this context, we address the following questions: (i) How many and which Brazilian anuran species are represented in these sound collections? (ii) Which of these species had their advertisement calls described in the literature? (iii) Is the number of recordings predicted by the species' body size (SVL—snout–vent length), geographical range, and years since the species was first described? (iv) Is there a phylogenetic bias in the number of recordings and is it affected by species diversity among and/or within families? (v) Which biome regions are less represented in these collections?

MATERIALS AND METHODS

We collected information on the location and the year of 15 sound collections (Fig. 1), as well as the number of recordings and number of anuran species (Table 1). To obtain these data, we contacted the curators of 20 sound collections in Brazil, of whom 15 responded and shared raw data about their anuran collection. We collated data from all institutions and allocated locations and species names (following Frost, 2025) to the recordings. We calculated the total number of acoustic recordings per species and obtained data with regard to the anuran species, in particular (i) years since it was described, (ii) body size (mm), (iii) conservation status, (iv) geographical range size, and (v) whether a formal acoustic description of the advertisement call was available in the literature. Data were obtained from: (i) Frost (2025), (ii) the literature on morphology (i.e. from original descriptions, field guides, natural history or review articles) for the average SVL of males or from collections in the absence of published data, (iii) the Brazilian red list (MMA, 2022), (iv) the IUCN Red List of Threatened Species (https://www.iucnredlist.org/) for geographical range data, and (v) the literature on bioacoustics (only textual description of the calls was considered). We searched for descriptions of advertisement calls in recently published reviews (e.g. Guerra *et al.* 2018, Rivera-Correa *et al.* 2021), as well as on the Scopus (https://www.scopus.com), Scielo (https://www.scielo.br/), and Web of Science (https://www.webofscience.com) databases using the combination of keywords in Guerra *et al.* (2018).

To avoid sampling bias, we only considered species listed for Brazil in the database provided by Frost (2025) and excluding recordings of undetermined species ('sp.', 'cf', 'gr.', and 'aff.'). As we expected, newly created collections house fewer recordings than older ones. We used a simple linear regression analysis between the number of anuran records and the year the acoustic collection was created. We used simple linear regressions to test whether the number of recordings for each family (response variable) was influenced by species richness within the family considering our dataset.

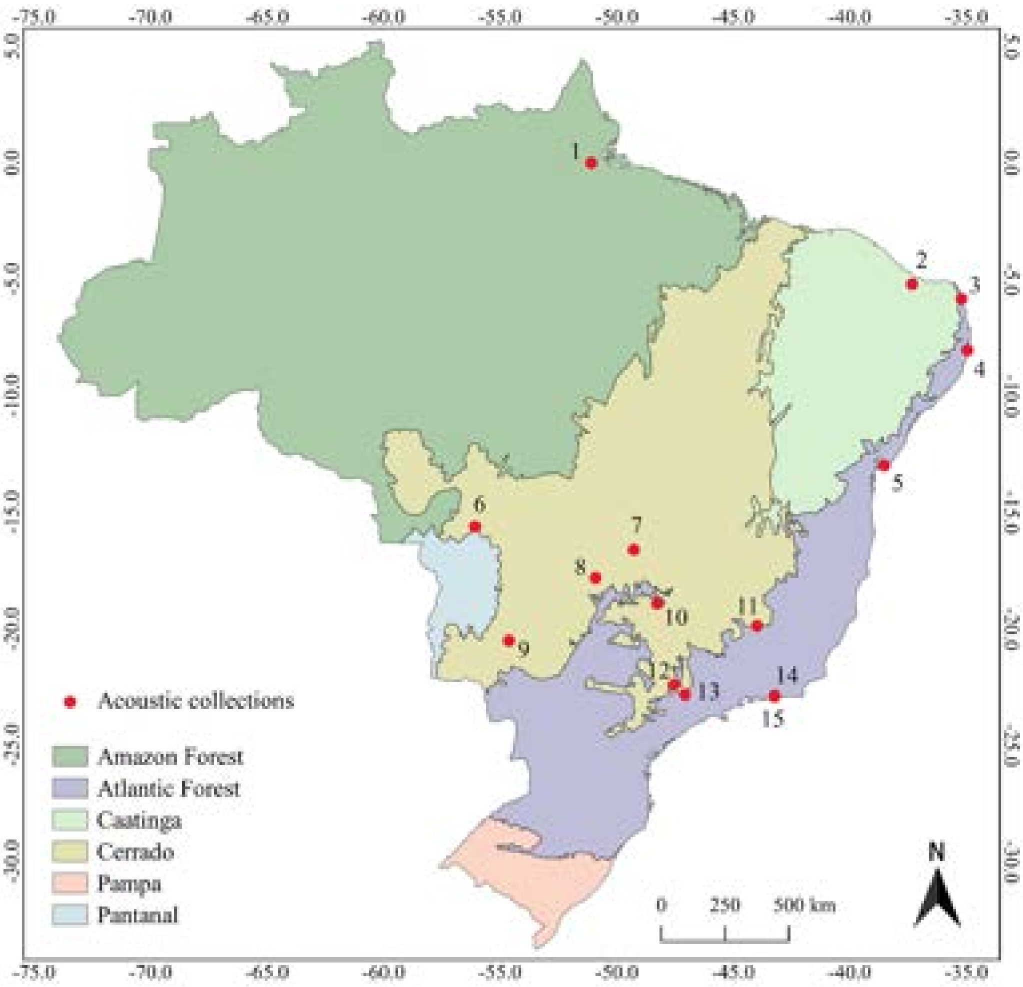

Figure 1. Geographical distribution of the sound collections included in this study.

Table 1. The name, location (municipality, state), number of species, number of recordings and curator of each of the 15 Brazilian sound collections considered in this study.

Collection	Affiliation	Location	Number of species	Number of recordings	Curator
AAG-UFU	Universidade Federal de Uberlândia	Ituiutaba, MG, Brazil	371	10 398	Ariovaldo A. Giaretta
Arquivo Sonoro do Laboratório de Anfíbios e Répteis	Universidade Federal do Rio de Janeiro	Rio de Janeiro, RJ, Brazil	124	1732	Sergio Potsch de Carvalho
Banco de Registros Bioacústicos Laboratório de Herpetologia do Instituto de Biociências	Universidade Federal de Mato Grosso	Cuiabá, MT, Brazil	203	1627	Christine Strüssmann
Coleção 'Célio F. B. Haddad'	Universidade Estadual Paulista	Rio Claro, SP, Brazil	152	833	Célio F.B. Haddad
Coleção Audiovisual do Semiárido—CASA	Universidade Federal Rural do Semi-Árido	Mossoró, RN, Brazil	17	268	Milena Wachlevski
Coleção Científica de Vocalizações de Anfíbios Anuros	Museu Nacional	Rio de Janeiro, RJ, Brazil	155	815	José Perez Pombal Júnior
Coleção de Arquivos Sonoros de Anuros Neotropicais	Instituto Federal Goiano	Rio Verde, GO, Brazil	29	663	Alessandro R. Morais
Coleção de Bioacústica e Ecologia Acústica do Museu de Ciências Naturais	Pontifícia Universidade Católica de Minas Gerais	Belo Horizonte, MG, Brazil	33	35	Marina Henriques Lage Duarte
Fonoteca Biológica	Universidade Federal de Pernambuco	Recife, PE, Brazil	30	75	Pedro Ivo Simões
Fonoteca da Universidade Federal de Goiás (FONO–UFG)	Universidade Federal de Goiás	Goiânia, GO, Brazil	72	1847	Rogério P. Bastos
Fonoteca Neotropical Jacques Vielliard	Universidade Estadual de Campinas	Campinas, SP, Brazil	621	5830	Luís Felipe Toledo
Fonotropica	Universidade Federal da Bahia	Salvador, BA, Brazil	35	263	Lucas Rodriguez Forti
Arquivos Sonoros da Universidade Federal do Rio Grande do Norte	Universidade Federal do Rio Grande do Norte	Natal, RN, Brazil	119	691	Adrian Garda
Fonoteca Mapinguari	Universidade Federal do Mato Grosso do Sul	Campo Grande, MS, Brazil	97	326	Diego José Santana
Fonoteca Muiraquitã	Universidade Federal do Amapá	Macapá, AP, Brazil	61	426	Carlos Eduardo Costa Campos

To improve the linearity of the relationships and reduce skewness of the covariates, we transformed the geographical distribution range into $\log_{10}$(Range+1) scale and mean-centred the Year variable, which facilitates the interpretation of the intercept and reduces collinearity among terms. Body size (SVL) was kept in its original scale (mm) as it did not show major discrepancies. The response variable of number of recordings initially showed overdispersion in variance, violating one of the assumptions of the analysis. To address this, we used a generalized linear model with a negative binomial distribution, which is appropriate for count data with overdispersion. Finally, the final model was inspected for the assumptions of collinearity, normality, and homogeneity of residuals, and was found to be consistent with the assumptions of the analysis (Zuur *et al.* 2010). We used the R software (R Core Development Team 2021) to compute our analyses.

Model selection was carried out by comparing all possible combinations of predictor variables using the Akaike Information Criterion corrected for small sample sizes (AICc). Seven competing models were evaluated, ranging from the null model (intercept only) to the full model including all variables (Zuur *et al.* 2010). The model with the lowest AICc was selected as the most parsimonious, with the best predictive power to explain the number of vocalization records in the acoustic collections. For visualization, we also transformed the response variable into log(Recordings+1) exclusively in the plots, in order to stabilize variance and allow clearer recognition of patterns without a few high values dominating the scales.

We also tested whether the number of recordings exhibits phylogenetic structuring. Recent evidence indicates that even traits seemingly unrelated to evolutionary history may display such patterns (Forti *et al.* 2022). For example, inherited features such as body size or boldness during calling could influence the probability of being detected and recorded, thereby introducing a phylogenetic bias in sampling effort. To assess this, we evaluated whether closely related species tend to have similar numbers of recordings. Specifically, we applied Blomberg's K and Pagel's λ tests (Pagel 1999, Blomberg *et al.* 2003) to the number of recordings, using 1000 randomizations for significance testing ($P < .05$) implemented in the phytools package (Revell 2012). Values of $K < 1$ and λ close to zero indicate that the variable is not congruent with the phylogeny, i.e. the number of recordings is less similar to each other for phylogenetically closely related species than expected under the Brownian motion model (BM) of trait evolution. On the other hand, K and λ close to 1 indicate that the number of recordings is close to the BM prediction. Finally, $K > 1$ indicates that the pattern for the number of recordings is more similar among closely related species than predicted by the BM (λ values vary between 0 and 1 only). For this analysis, we used the phylogenetic tree provided by Jetz and Pyron (2018). We included 627 species in the phylogenetic tests, removing 92 taxa from our dataset that were not included in Jetz and Pyron's tree. The remaining 6612 amphibian species and outgroups were pruned from the tree.

RESULTS

We gathered 25385 anuran recordings deposited in 15 sound collections in Brazil (see Supporting Information). The number of acoustic recordings was unevenly distributed in the collections (Table 1), with most recordings ($N = 10\,398$; 40.96%) housed in the acoustic repository of the AAG-UFU, followed by the Fonoteca Neotropical Jacques Vielliard ($N = 5830$; 22.96%). The total number of acoustic recordings per collection was not correlated with the age of the collection ($R^2 = 0.12$; $P = 0.27$).

Taxonomic representation in sound collections

Considering all collections, 798 anuran species belonging to 24 families were represented, with 22298 recordings of 725 Brazilian native species and 178 recordings of 73 species that do not occur in Brazil. The list of native species represented in the collections represents 62.9% of all anuran species occurring in Brazil. Undetermined species ('sp.', 'cf', 'gr.', and 'aff.') represented 2909 (11.46%) recordings.

The number of acoustic recordings was also unevenly distributed among anuran families. Hylidae and Leptodactylidae were the most represented, with 52.53 and 23.36% of all recordings, respectively. The most underrepresented families were Allophrynidae, Alsodidae, Aromobatidae, Centrolenidae, Ceratophryidae, Cycloramphidae, Dendrobatidae, Eleutherodactylidae, Hemiphractidae, Pipidae, and Ranidae, which together represented less than 3% of the records. Considering only native species, the number of recordings per family was related to the number of species described in each family ($R^2 = 0.942$; $N = 20$ families; $P < 0.001$; Fig. 2).

The 10 most represented species were: *Scinax fuscomarginatus* (Lutz, 1925) ($N = 861$ recordings), *Dendropsophus minutus* (Peters, 1872) ($N = 535$), *Dendropsophus nanus* (Boulenger, 1889) ($N = 431$), *Physalaemus cuvieri* Fitzinger, 1826 ($N = 395$), *Dendropsophus cruzi* (Pombal and Bastos, 1998) ($N = 361$), *Boana albopunctata* (Spix, 1824) ($N = 355$ recordings), *Boana albomarginata* (Spix, 1824) ($N = 308$), *Leptodactylus fuscus* (Schneider, 1799) ($N = 281$), *Boana goiana* (Lutz, 1968) ($N = 256$), and *Boana polytaenia* (Cope, 1870) ($N = 250$).

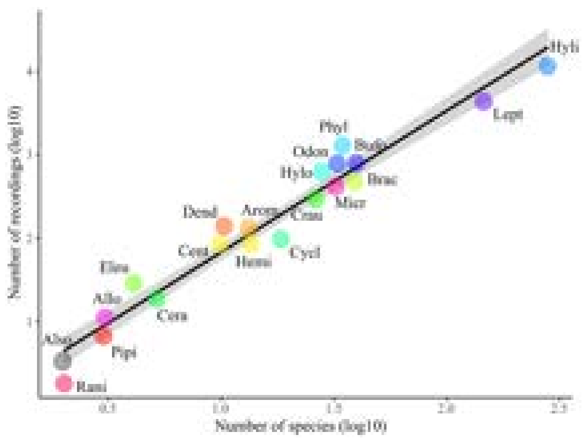

Figure 2. The number of recordings in 15 Brazilian amphibian sound archives as a function of species richness in each anuran family. The colours of the circles match those used to represent each family in the phylogenetic tree.

No species had audio files deposited in all sampled collections. However, *Dendropsophus minutus* ($N = 14$ collections), *Physalaemus cuvieri* ($N = 13$), *Leptodactylus fuscus* ($N = 12$), *Boana faber* ($N = 12$), *Scinax fuscomarginatus* ($N = 11$), *Boana albopunctata* ($N = 11$), *Dendropsophus nanus* ($N = 10$), *Scinax x-signatus* ($N = 10$), *Pithecopus hypochondrialis* ($N = 10$), and *Rhinella granulosa* ($N = 10$) had records deposited in 10 or more acoustic collections, whereas 268 species were represented in only one collection. Twenty-six species (3.26% of the 798 species) with recordings deposited in collections did not have their advertisement calls described in the literature.

Male body size (SVL) of the analysed species ranged from 8.7 to 170 mm (32.3 ± 21.06 mm, mean ± SD), and geographical range size varied from 0.37 to 12 048 757.37 km^2 (878 854.9 ± 1779 356 km^2, mean ± SD). The year of species description ranged from 1758 to 2021 (Supporting Information, Table S1). Based on this dataset, the best-fitting model to explain the number of recordings in sound collections included the variables geographical range size, SVL, and the year of description (AICc = 5421, ΔAICc = 0.75). This model showed a pseudo R^2 of 25.1%, explaining one-quarter of the total variability in the data.

The selected model indicated a significant positive effect of geographical range size (Estimate = 0.17, $z = 10.52$, $P < 0.01$) and a significant negative effect of SVL (Estimate = −0.01, $z = -4.72$, $P < 0.01$), indicating that species with broader geographical distributions and smaller body sizes tend to be more represented in acoustic collections (Fig. 3). The year of description was also present in the full model selected and showed a negative effect (Estimate = −0.002, $z = -3.07$, $P < 0.01$), but this effect was lower (Fig. 3), suggesting that the date of species description may does not have a relevant impact on the number of recorded calls.

Phylogenetic representation of the sound collections

Although Pagel's λ and Blomberg's K were relatively low (λ = 0.214, $P = 0.000$; $K = 0.169$, $P = 0.026$), both tests showed significant values, indicating congruence between number of recordings and phylogenetic position. Therefore, species with many recordings generally belonged to the same lineages (Fig. 4). For instance, *Aplastodiscus*, *Boana*, *Dendropsophus*, *Leptodactylus*, *Physalaemus* species, members of a clade mostly composed of species of the *P. cuvieri* group (*P. albifrons*, *P. albonotatus*, *P. centralis*, *P. cuvieri*, and *P. ephippifer*) and *Pseudopaludicola* represented a large proportion of recordings.

Representation of sound collections by Brazilian biome

The largest number of recordings were obtained within Brazil ($N = 23\,781$ recordings), but, besides Brazil, there were acoustic recordings from 17 other countries, representing 1.4% of the data. Collections had different representativeness of countries with associated acoustic data. All 18 countries were represented in Fonoteca Neotropical Jacques Vielliard, whereas six collections

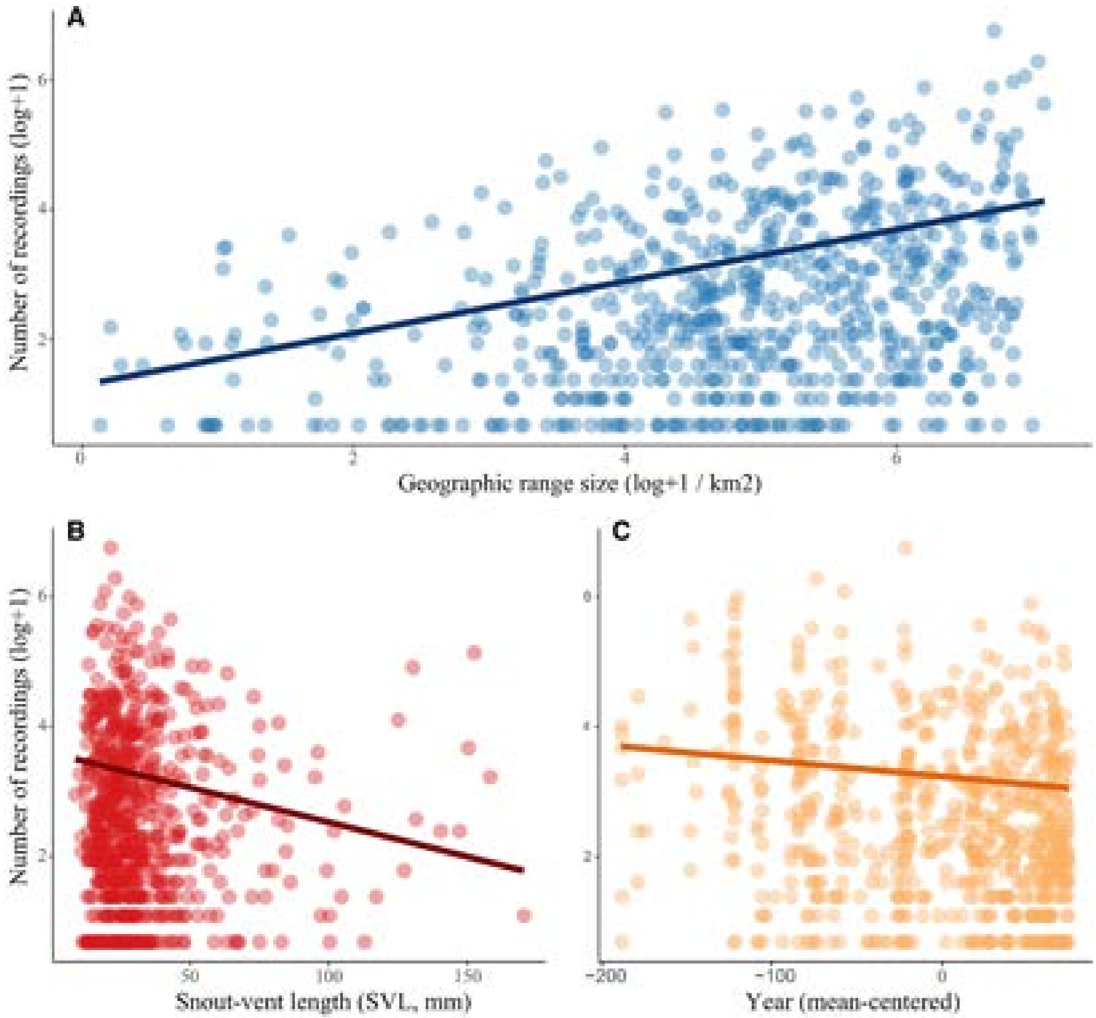

Figure 3. The number of recordings as a function of geographical range size (A), snout–vent length (B), and year of species description (C) of the calls archived in Brazilian acoustic collections.

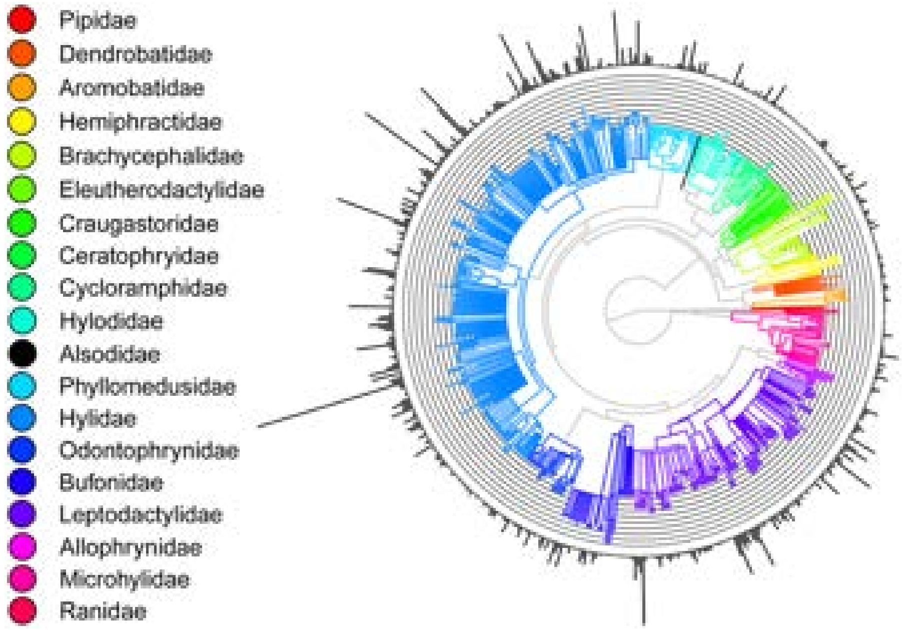

Figure 4. Phylogenetic tree from Jetz and Pyron (2018) with the anuran species present in 15 Brazilian amphibian sound archives. Colours indicate the family of species with sound archives. Black bars at the tip of the trees indicate the number of recordings per species.

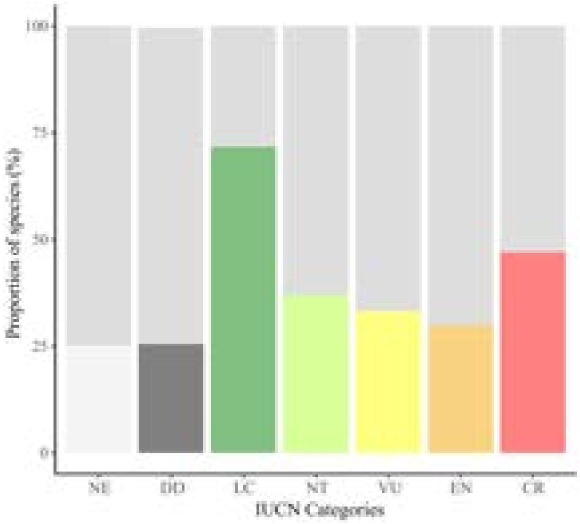

Figure 5. The proportion of anuran species with (colour gradient) and without (grey colour) recordings in 15 Brazilian sound collections that belong to different IUCN threat categories in the Brazilian Red List (MMA 2022).

had recordings obtained exclusively in Brazil. The records obtained in Brazil include anuran species occurring across the country's six main biomes, with 506 species from the Atlantic Forest, 323 from the Cerrado, 237 from the Amazon Rainforest, 154 from the Caatinga, 83 from the Pantanal, and 75 from the Pampa.

Endangered species in Brazilian sound collections

Based on species native to Brazil ($N = 725$), most recordings covered non-threatened species, of which 21420 (76.8%) recordings of 633 species were classified as Least Concern (LC) and 71 (0.8%) recordings of 10 species were classified as Near Threatened (NT). Sound recordings of threatened species included 26 (0.5%) recordings of five Vulnerable (VU) species, nine (0.3%) of three Endangered (EN) species, and 90 (0.1%) of 16 Critically Endangered (CR) species. Finally, 198 (2.6%) recordings were of 22 Data Deficient (DD) species and 483 (5.8%) recordings were of 35 Not Evaluated (NE) species. Of all species found in Brazil, our dataset covered 71.69% of LC, 37.04% of NT, 33.33% of VU, 30% of EN, 47.06% of CR, 25.58% of DD, and 25.18% of NE species (Fig. 5).

DISCUSSION

Conducting the first large-scale assessment of anuran recordings deposited in sound collections in Brazil, we identified taxonomic, phylogenetic, and geographical biases among these audio recordings. Our knowledge of the bioacoustics of anuran species has expanded considerably in the last few decades (Köhler *et al.* 2017), particularly in Brazil, where in recent years more researchers have considered bioacoustics to be an important field of research (Bastos *et al.* 2021). Consequently, researchers around the country have focused on acoustic sampling of anurans during field activities (Guerra *et al.* 2018). Nevertheless, before the present study, knowledge about the recordings deposited in the acoustic collections was scarce.

Audio recordings deposited in Brazilian acoustic collections cover 60.4% of 1200 anuran species currently registered in Brazil (Frost 2025). In an earlier study, Bastos *et al.* (2021) found that only 72.6% of the anuran species in Brazil had their advertisement calls described in the literature. The discrepancy between these values indicates that many researchers who describe anuran vocalization do not deposit these recordings in acoustic collections. This reinforces the call for better practices of data management and availability (Dena *et al.* 2020, Mendoza-Henao *et al.* 2021). There may be additional anuran species with recorded vocalizations than reported in the present study. Frequent destinations for sound archives include personal or institutional acoustic collections that are not broadly publicized or divulged, and therefore are hard to reach. Acoustic recordings obtained for many anuran species in the last few decades may also have been lost due to inadequate management of recording media (Dena *et al.* 2020).

On the other hand, the calls of 26 anuran species that have had their recordings deposited in Brazilian sound collections have not yet been described in the literature. Acoustic information deposited in collections represents a good opportunity for collaboration among researchers, potentially contributing to advances in understanding the ecology and taxonomy of Neotropical anurans (e.g. Forti *et al.* 2019, Dena *et al.* 2024). Our survey revealed that approximately 8% of all available anuran recordings had incomplete metadata, in particular geographical information, which compromises the usefulness of the data. Complete time, climate, and location data are crucial for analysis, and both field researchers and collection curators should ensure that metadata associated with recordings are as complete as possible (see Köhler *et al.* 2017 for suggestions on field data standardization).

Recordings deposited in sound collections in Brazil are taxonomically biased. Species-rich families had more audio recordings deposited than less diverse families. Similar results have been reported in previous studies (Guerra *et al.* 2018, Rivera-Correa *et al.* 2021). In their review on published anuran bioacoustics studies conducted in Brazil, Guerra *et al.* (2018) found that more than half of the species in their dataset belonged to the two most representative anuran families (i.e. Hylidae and Leptodactylidae, the same as in our dataset), whereas advertisement calls of anuran families with restricted distributions and with many recently described species were less studied. A potential explanation for this pattern is that individuals of species of the most represented families form large aggregations during the breeding season, which allows for high-quality recording of many individuals in a given location (Rivera-Correa *et al.* 2021). In addition, our results also highlighted that species with a large number of audio recordings usually belong to the same phylogenetic lineages (i.e. clades of the genera *Aplastodiscus*, *Boana*, *Dendropsophus*, *Leptodactylus*, *Pseudopaludicola*, and *Physalaemus*), indicating that recordings are not uniformly distributed across clades. We presume that some anuran lineages are probably better studied than others because systematists often have specific taxonomic targets. Once acoustic signals provide taxonomic evidence (Ryan 1983, Forti *et al.* 2017, Hepp and Pombal 2020), the number of recordings including advertisement calls is likely to be influenced by the interest of taxonomists.

The 10 most represented anuran species in our dataset are also frequent biological models in bioacoustics experiments (i.e. Morais *et al.* 2012, Toledo *et al.* 2015, Guerra *et al.* 2018, Andreani *et al.* 2020, Bastos *et al.* 2021). For instance, *Dendropsophus minutus* was the best represented species in the acoustic collections, and this species has been a research target for bioacoustics approaches in Brazil (Morais *et al.*, 2012, Foratto *et al.* 2021). Species with recordings deposited in different, widely distributed collections represent an excellent opportunity for collaboration in large-scale ecological, evolutionary, and taxonomic studies. On the other hand, we observed that dozens of species have their recordings deposited in only a few collections. As our dataset comprises information provided by national and regional collections, many species probably have their recordings deposited only in a regional collection. These regional collections can help to fill taxonomic, geographical, and temporal gaps in our understanding of biodiversity at a large scale (Monfils *et al.* 2020).

Body size, geographical distribution, and years since the species description affect the detectability of anuran species and these factors have been explored in different contexts (i.e. Diniz–Filho *et al.* 2005, Oliveira *et al.* 2019, Guerra *et al.* 2020). Herein, we show that large or poorly sampled species have fewer recordings deposited in sound collections. Therefore, our findings indicate that underrepresented species are more difficult to detect during field activities and, consequently, they tend to be poorly represented in acoustic collections. In particular, we suggest that it is more difficult to record large and poorly sampled anuran species, because they tend to have lower population density or occur in difficult-to-reach areas or environments. Another explanation for the low representation of large species that are abundant (e.g. *Rhinela* spp. and *Leptodactylus* spp.) may be associated with different objectives of acoustic studies that did not consider these species. Additionally, widely distributed species that are locally abundant have several individuals recorded at each location. These records increase the representativeness of individuals locally and reduce the chance that calls are individual variations avoiding biases in biogeographical, ecological, and evolutionary studies.

Less than 2% of acoustic records deposited in Brazilian acoustic collections come from other countries. FNJV was created in the late 1970s and currently is the most internationally recognized Brazilian acoustic collection (Ranft 2004, Köhler *et al.* 2017). It is therefore no surprise that this acoustic collection had the highest number of countries represented. On the other hand, six acoustic collections housed acoustic recordings exclusively from Brazil. Most of these collections were established in the last 10 years and have a regional scope. Nevertheless, they play an important role, as they house recordings of unique specimens, collected in places that are poorly represented in collections with a national coverage.

We presume that the number of recordings is not affected by the age of the sound collections due to some idiosyncratic features related to the range of the collaborators' network and the public system for data input of these collections. Both properties may affect the rate at which recordings are deposited. Therefore, independently of its age, a sound collection with technicians to assist with deposits or having easy steps to data input, in association with a lab that supports a larger network of researchers participating in amphibian fieldwork, will increase the number of recordings faster than collections not having these services and fewer collaborators. Bastos *et al.* (2021) found that most researchers dedicated to anuran bioacoustics were based at institutions in the central western and south regions. As these regions host a high biodiversity, as well as threatened ecological domains, such as the Atlantic Forest and Cerrado biomes (Mittermeier *et al.* 2005), these records are highly relevant in the documentation of Brazil's biodiversity. On the other hand, although northern Brazil is mostly covered by the Amazon rainforest, one of the most biodiverse tropical forests on the planet, there were relatively few recordings and we did not obtain information on acoustic collections from this region. Other ecological domains such as the Brazilian semi-arid (including Caatinga) and Pampa grasslands, located in the north and south, respectively, are historically neglected in terms of their biodiversity (Overbeck *et al.* 2007, Silva *et al.* 2017), which can explain the low representation of acoustic recordings in these regions. Although this may be a reality for anuran bioacoustics, we interpret this result with caution because some collections that could house recordings from these regions did not contribute for our dataset.

Amphibians are the most threatened terrestrial vertebrate group on the planet (Luedtke *et al.* 2023). However, being classified within a threat category does not imply increased monitoring (Guerra *et al.* 2018, Silva *et al.* 2020, Rivera-Correa *et al.* 2021, Teodoro *et al.* 2022). Similarly, there were few acoustic records of endangered species in our dataset. Threatened species tend to be less well studied, because they have a restricted geographical distribution and low population density, or occur in inaccessible regions with poor infrastructure for research (Silva *et al.* 2020). On the other hand, considering that passive acoustic monitoring has been widely used in Brazil (Duarte *et al.* 2019, Melo *et al.* 2021), recordings deposited in the acoustic collections could be used to discover new populations of threatened species, because these files could be used to calibrate automatic species identification methods.

Our results provide a clearer picture of the acoustic recordings of anuran species deposited in 15 sound collections in Brazil, allowing us to identify opportunities and challenges. We hope that our dataset will help to attract funding for future studies, such as those describing the vocalizations of anuran species or acoustic variability at different levels (within-individual, between-individual, along the year, among breeding seasons, among populations, etc.) of those species that are more representative in our dataset (see examples in Andreani *et al.* 2020, Souza *et al.* 2023). We also reinforce the three actions proposed by Mendoza-Henao *et al.* (2021): '1) researchers should deposit recordings used in published research in national or regional acoustic repositories, 2) publishers and paper reviewers should require authors to provide deposit numbers of all files used in any acoustic research and the correct referencing of the collections used in order to accept manuscripts and, 3) the managements of regional institutions with repositories should ensure that institutional acoustic repositories are strengthened and maintained in the long term.'

Acoustic collections in Brazil should expand their visibility through better integration with the general public. Brazil has many naturalists who contribute data through citizen science platforms (Forti and Szabo 2023). Therefore, collections should encourage citizen science programmes, involving volunteers as potential collectors. Recordings can go beyond the hands of academics, and efforts can extend the representativeness of natural sounds in acoustic collections. We encourage the creation of more bioacoustics collections, mainly in institutions in underrepresented regions and focusing on understudied lineages, and also strengthening of existing acoustic collections, especially those that are newly created and regional. Finally, we encourage all collections to make their data available online, facilitating access, increasing visibility, and strengthening cooperative research among herpetologists.

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SUPPLEMENTARY DATA

Supplementary data is available at *Biological Journal of the Linnean Society* online.

CONFLICT OF INTEREST

None declared.

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DATA AVAILABILITY

The data underlying this article are available in the article and in its online Supporting Information.

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