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Reptiles of the Atlantic Forest, Espírito Santo, Brazil: Using Two Complementary Citizen Science Data Sources

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***Abstract*.—We present a pioneering survey of public contributions to the understanding of reptile diversity in the Atlantic Forest of the state of Espírito Santo (ES), Brazil. We used the zoological collection of the National Institute of the Atlantic Forest and records from the iNaturalist platform (web), specifically the project *Eu conheço os répteis daqui!* (I know the reptiles from here!). The dataset comprised 1,215 observations, spread across 53 cities, with 102 species, 37 of which are endemic to the Atlantic Forest, and 13 of which are threatened with extinction. The most frequently recorded species were the Jararaca (*Bothrops jararaca*; n = 157), the Amazon Lava Lizard (*Tropidurus torquatus*; n = 133), and the Black and White Tegu (*Salvator merianae*; n = 50). We demonstrate that public participation in scientific research is crucial for enhancing biodiversity knowledge. It effectively generated a high-quality dataset, revealing a significant portion of known reptile species and provided new occurrence records in ES. Our study highlights how the use of two complementary citizen science data sources contributes to an improved understanding of the composition and geographic distribution of reptiles in the Atlantic Forest.**

Key Words.—collaborative platform; data quality; iNaturalist; herpetofauna; museum data; scientific collection

Introduction

Citizen science (CS) represents a collaborative research process between scientists and volunteers across various topics (Bonn et al. 2016), and has been successfully implemented in diverse scientific fields, such as biology, ecology, and conservation (Frigerio et al. 2018). The practice of data collection for scientific purposes through public participation has a historical legacy spanning centuries (Miller-Rushing et al. 2012). Currently, CS extends beyond academic experts, engaging diverse social actors at varying levels in scientific research for knowledge production (Bonney et al. 2009; Becker-Klein et al. 2016). This engagement facilitates community decision-making regarding environmental issues (Bonney et al. 2015) and fosters social capital for collective action (Cunha et al. 2017), holding the potential to tackle community challenges (Overdevest et al. 2004; Toomey and Domroese 2013).

Globally, there are CS projects that contribute data on herpetofauna (e.g., Pittman and Dorcas 2006; Weber et al. 2016; Liebgold et al. 2019; Wangyal et al. 2020; Glorioso et al. 2022); however, the number of such projects is modest compared to those focused on birds, butterflies, and plants (Chandler et al. 2017; Price and Dorcas 2011). Additionally, in some regions of the world, reptiles are feared or despised by the public (Alves et al. 2012), which may reduce public involvement in monitoring efforts. Nevertheless, herpetofauna monitoring programs have been successful in the USA, for example in Wisconsin (Casper 1996), New York (Gibbs et al. 2007), Georgia (Jensen et al. 2008), and the North and South Carolinas (Price and Dorcas 2011). The databases generated from these projects are significant because they enhance our understanding of the composition, distribution, conservation status, and biology of various taxonomic groups (O'Donnell and Durso 2014).

In addition to creating large databases, scientific institutions and biological collections are vital resources for engaging the public in science by contributing to the understanding and conservation of biodiversity. Considering reptiles, examples of such impacts and applications include: (1) monitoring turtle nests in Brazilian Amazonia with public participation (Norris et al. 2018); (2) developing and applying applications to assist the public in identifying true coral snakes in the state of Minas Gerais (Silva et al. 2021); and (3) a recent evaluation of trophic interactions (predator-prey) among Brazilian birds that prey on snakes, using photographs from collaborators on the WikiAves platform (Souza et al. 2022).

In Brazil, significant volunteer participation in reptile research began in a pioneering way through the donation of venomous snakes to the Butantan Institute, long before the term citizen science was used in scientific literature. This campaign was championed and encouraged by Vital Brazil, a scientist in the early 20th Century (Teixeira et al. 2015), who aimed not only to build a substantial collection of these organisms but also to create a bank to produce antivenom serum to save human lives. Public participation in ecological and socio-environmental studies in Brazil remains limited, however, especially in research focusing on herptiles (e.g., Norris et al. 2018; Silva et al. 2021; Souza et al. 2022).

The potential for CS in Brazil is significant, given its status as a megadiverse country with over 211 million inhabitants (https://www.ibge.gov.br/estatisticas/sociais/populacao/9109-projecao-da-populacao.html) that needs to address various environmental, economic, and social challenges. Historically, the Brazilian Atlantic Forest (AF) has been consistently modified since the beginning of Brazilian colonization in the 16th Century, primarily due to deforestation and resulting landscape changes (Leal and Câmara 2003), particularly in the last century. The AF is recognized for its immense biodiversity, housing one of the richest reptile diversities on the planet (Myers et al. 2000; Tozetti et al. 2017). Despite this, there are significant biodiversity shortfalls (e.g., Linnean taxonomy, Wallacean distribution, Prestonian abundance, and Eltonian biotic interactions; see Hortal et al. 2015 for definitions) and a limited number of inventories and publications, even in the heavily populated Southeast Region, especially in the state of Espírito Santo (ES; Costa and Bérnils 2018). Thus, CS presents an excellent opportunity to monitor and fill knowledge gaps about the diversity of the AF, in a country currently grappling with budget cuts and a scarcity of funding for scientific research (Overbeck et al. 2018).

The number of species on the planet remains uncertain; nonetheless, there is consensus that we are far from cataloging even half (González-Oreja 2008; Engel et al. 2021) of the species that exist. Given the biodiversity crisis, it is indisputable that many species could become extinct in the coming decades due to human activities (Engel et al. 2021). Citizen science data are often submitted to various online platforms, such as iNaturalist (https://www.inaturalist.org), eBird (https://ebird.org/home), and the Global Biodiversity Information Facility (https://www.gbif.org), or deposited in biological collections, contributing significantly to biodiversity research. These platforms and collections serve as repositories for a vast amount of observational and specimen data. Integrating these data sources is crucial for obtaining a comprehensive understanding of the biodiversity in a given locality, leading to better-informed conservation and management strategies (Chandler et al. 2017).

To evaluate the potential of citizen science for studying the biodiversity of reptiles in the Atlantic Forest of ES, Brazil we used citizen science data from two sources (iNaturalist and museum collections) and analyzed the contribution of each data source to the understanding of species richness, diversity according to clades, number of AF endemic species, degree of threat, and geographical distribution. Also, we analyzed the number of contributors from both sources and the accuracy of species identifications by iNaturalist contributors. From a methodological perspective, we evaluated and discussed the contribution and efficiency of each source in providing data in terms of quantity, quality, and period.

Materials and Methods

Data collection and analysis.—Our survey was based on contributions from different data sources of reptile occurrences: the records of specimens donated by non-specialists to the Museu de Biologia Professor Mello Leitão (MBML), hosted at the National Institute of the Atlantic Forest (INMA), and the records on the iNaturalist web platform submitted by citizen scientists collaborating with the project *Eu conheço os répteis daqui!* (I know the reptiles from here!). We analyzed data from both sources (MBML/INMA and iNaturalist) for the state of Espírito Santo

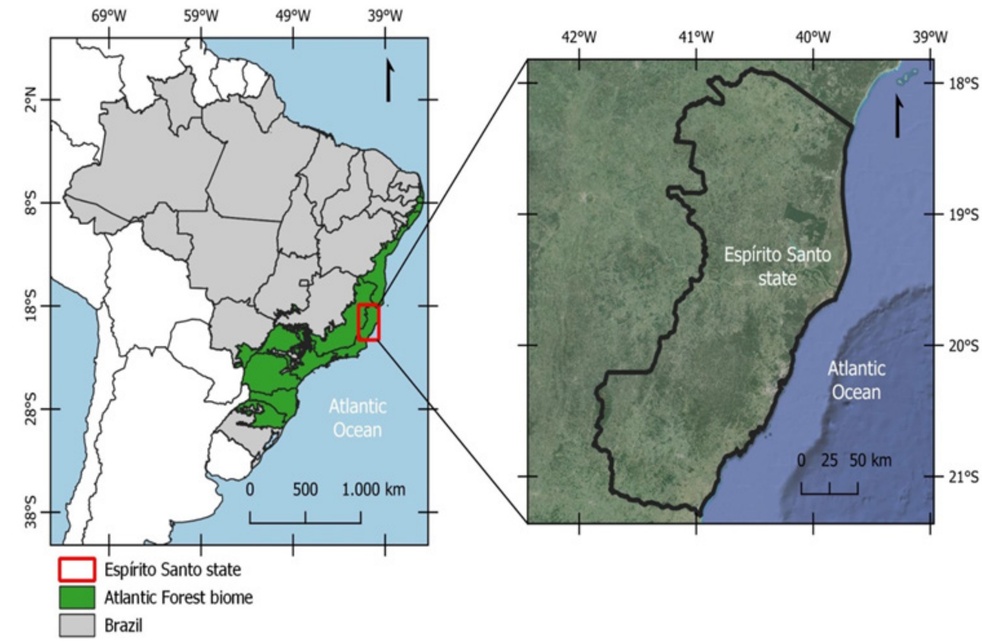

Figure 1. (Left) Study area, in southeastern Brazil, South America, showing the state of Espírito Santo (red square), Atlantic Forest biome (green), and Brazil (gray). The satellite image on the right highlights the state of Espírito Santo (Source: Google Earth).

- ES (Fig. 1), focusing on: (1) the total and relative (%) frequency of species, specimens, and taxonomic groups (clades: amphisbaenians, chelonians, crocodilians, lizards, and snakes); (2) the number of endemic species of the AF (based on Costa and Bérnils 2018); (3) species threat rank according to ES state list of threatened species (International Union for Conservation of Nature [IUCN] 2018; Fraga et al. 2019): Vulnerable (VU), Endangered (EN), and Critically Endangered (CR), or Data Deficient (DD); and (4) the total and average number of reptile records made by collaborators over time to account for the historical dynamics of public participation. Species identifications were validated by herpetologists, defined according to the Brazilian List of Reptiles - Brazilian Society of Herpetology - SBH (Costa and Bérnils 2018). Additionally, we considered two alien invasive species introduced in Brazil, the African lizard the Tropical House Gecko (*Hemidactylus mabouia*) considered in the Brazilian List of Reptiles (Costa and Bérnils 2018) and the North American turtle the Red-eared Slider (*Trachemys scripta*). Both of these species are widely distributed and present well-established free-living populations in Brazil for centuries and decades, respectively. For our purposes, we discarded records of exotic species only in captive conditions (e.g., laboratories or zoos) as their locations do not reflect the occurrences of their free natural populations in the wild. We assigned English common names of the species, when existing, according to The Reptile Database (http://www.reptile-database.org) and/or the IUCN Red List (https://www.iucnredlist.org).

Museum and iNaturalist records.—We retrieved data from the MBML/INMA, situated in the municipality of Santa Teresa, Espírito Santo (ES), from the SpeciesLink platform (https://www.splink.org.br). We considered only specimens donated by non-specialists from March 1969 to August 2022. Thus, we were able to assess the importance of the contribution of lay donations to the entire reptile collection in the state of ES. Such donated specimens have been found dead by people in their homes, local rural areas, or run over on roads. We refined all identifications along with our reptile specialist partners of the project *Eu conheço os répteis daqui!* To ensure that our data included only contributions from citizen scientists, we checked the names of the collectors as recorded in the registry spreadsheet of the collection. We aimed to exclude data obtained by professional researchers, subject matter specialists, or academics. This verification process involved consulting the names and curriculum vitae of researchers registered on the Lattes Platform of the Brazilian National Council for Scientific and Technological Development/CNPq (https://buscatextual.cnpq.br/buscatextual/busca.do?metodo=apresentar). We relied on personal consultations with the longest-serving staff and collaborators of the museum. Doubtful or unconfirmed names were excluded from the dataset.

We used data from the collaborative platform iNaturalist for 3 January 2000 to 31 August 2022. For this purpose, we created the project profile *Eu conheço os répteis daqui!* (https://www.inaturalist.org/projects/eu-conheco-os-repteis-daqui) on the platform, focusing on the area of the ES state and referencing the list of native and introduced (alien invasive) species that live freely in nature (https://www.inaturalist.org/check_lists/7213-Brazil-Check-List) under the Class Reptilia. The data spreadsheet from iNaturalist, available for consultation and download, includes detailed information about the records and their geographical locations. It provides the number of observations and species registered by collaborators, and in the statistics section, the quantity and quality (percentage) of identifications. In this platform, the terms identifiers and observers refer to two different roles that users can take on within the platform. Observers are users who contribute by uploading their encounters with various organisms, including relevant details such as photographs and location data (i.e., non-specialists). They are crucial for data collection, enhancing the biodiversity database of the platform. In contrast, identifiers are users who review these uploads, using their knowledge to confirm or provide accurate species identifications (i.e., collaborator specialists). Thus, we obtained the quality of species identifications (IDs) based on established categories: (1) Research Grade (78.74% of records); (2) Needs Identification (13.44%); and (3) Casual (7.82%). In the analysis, we only considered records classified at the Research Grade level; all identifications were also refined by us and our reptile specialist partners.

Distribution and maps.—To understand the geographic distribution of reptile records in ES, we created distribution and heat maps (Kernel Density Estimations) based on georeferenced occurrence points (latitude and longitude), species richness, and the number of specimens from both data sources (MBML/INMA and iNaturalist). We used the DivaGis v.7.5.0.0 (https://diva-gis.org), and QGis 3.28.7 and 3.8.1-Zanzibar (radius size = 5 km, pixel size = 1 km) to produce such maps (https://download.qgis.org/downloads/).

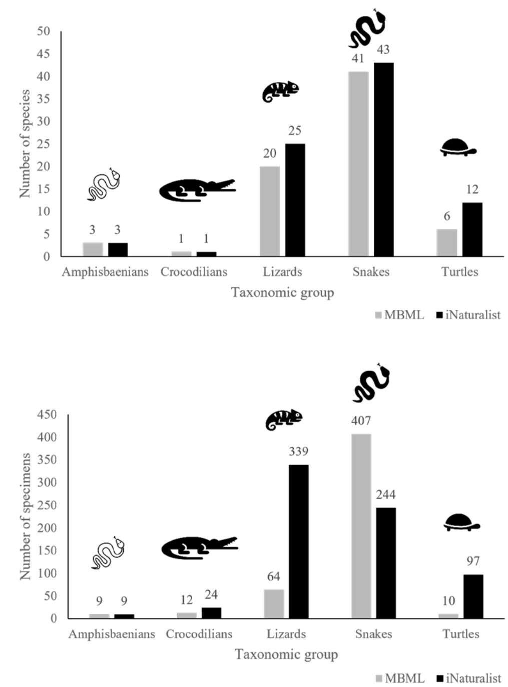

Figure 2. Total number of species (A; 102) and specimens (B; 1,215) of reptiles recorded according to taxonomic groups (clades) from the state of Espírito Santo, Brazil. Data separated according to the source used (Museu de Biologia Professor Mello Leitão - MBML/INMA and iNaturalist platform).

Results

We found 1,215 records from the iNaturalist dataset (n = 713; 58.7% of the sample) and the MBML/INMA dataset (n = 502; 41.3%). In total, we identified 102 species: 55 snakes, 29 lizards, 13 turtles, four amphisbaenians, and one crocodilian species (Supplemental Information Table S1). In terms of specimen counts by taxonomic groups, we recovered 651 snakes, 403 lizards, 107 turtles, 36 crocodilians, and 18 amphisbaenians (Supplemental Information Table S1). More species were reported in iNaturalist compared to MBML/INMA in most groups, except for amphisbaenids and crocodilians, which showed equivalent records (Fig. 2). In terms of number of specimens, iNaturalist surpassed MBML/INMA in nearly all taxonomic groups, except for snakes (Fig. 2). We report the possible first occurrence of the semi-arboreal snake Boettger's Sipo (*Chironius cf. flavolineatus*; Supplemental Information Table S1) for ES. We recorded 37 endemic species from the Atlantic Forest, two of which are also endemic to state, the lizards *Caparaonia itaiquara* (no common name) and False Tiger Anole (*Dactyloa pseudotigrina;* Supplemental Information Table S1). We recorded four Endangered (EN), six Vulnerable

Table 1. Reptiles donated to Museu de Biologia Professor Mello Leitão – MBML/INMA (1969 to 2022) and observed on the iNaturalist platform (2000 to 2022) by collaborators in the state of Espírito Santo, Brazil. The number (No.) of observations or records, number of species, the main group registered (MG; in numbers of species and specimens), time (years) and period sampled with mean of species registered/year, number of collaborators (No. C), identifiers (No. I; specialists), and cities in which specimens were recorded. The asterisk (*) is repeated specimens that were discarded. The most registered snakes from MBML/INMA were: Jararaca (*Bothrops jararaca*, n = 113); Forest Flame Snake (*Oxyrhopus petolarius*, n = 31); Goldbauch-Buntnatter (*Erythrolamprus poecilogyrus*, n = 29); Wied's Keelback (*Helicops carinicaudus*, n = 27); Jararacussu (*Bothrops jararacussu*, n = 23); and Painted Coral Snake (*Micrurus corallinus*, n = 23), and from iNaturalist were: *B. jararaca* (n = 44); Red-tailed Boa (*Boa constrictor*, n = 28); Patagonia Green Racer (*Philodryas patagoniensis*, n = 13); Lichtenstein's Green Racer (*Philodryas olfersii*, n = 12); and False Fer-de-lance (*Xenodon neuwiedii*, n = 12). The most recorded lizards from iNaturalist were: Amazon Lava Lizard (*Tropidurus torquatus*, n = 130); Black and White Tegu (*Salvator merianae*, n = 42); Tropical House Gecko (*Hemidactylus mabouia*, n = 38); Common Monkey Lizard (*Polychrus marmoratus*, n = 20); Spotted Anole (*Dactyloa punctata*, n = 18); and Giant Ameiva (*Ameiva ameiva*, n = 16).

Source	No. Records	No. Species	MG (No species)	MG (No specimens)	No. species/ year	No. C	No. I	No. Cities
MBML/ INMA	502	71	Snakes 43	Snakes 47	1969-2022 53 y, (1,3)	315	51	33
iNaturalist	713	84	Snakes 41	Lizards 339	2000-2022 22y (3,8)	182	263	44
Total	1215	102*				497	314	*53

(VU), and three Critically Endangered (CR) species for the state. Seven species are considered Data Deficient (DD; Supplemental Information Table S1). The most frequently recorded species were the Jararaca (*Bothrops jararaca*; n = 157), the Amazon Lava Lizard (*Tropidurus torquatus*; n = 134), and the Black and White Tegu (*Salvator merianae*; n = 50; Supplemental Information Table S1).

In the MBML/INMA collection, from 1969 to 2022, we recorded 71 species: 41 snakes, 20 lizards, six turtles, three amphisbaenians, and one species of crocodilian (Fig. 2). These were collected by 315 non-specialist observers (Table 1). The contributing public consisted primarily of residents, INMA staff, or INMA outsourced workers. The snakes group exhibited the highest number of species and specimens collected, with an average of 1.30 species recorded per year (Table 1). For museum data that included a record of the collection year (466 of 502 records), the most substantial contributions occurred in the early and late 1990s and mid-2000s. This was followed by a consistent decline in contributions from 2010 onwards (Fig. 3).

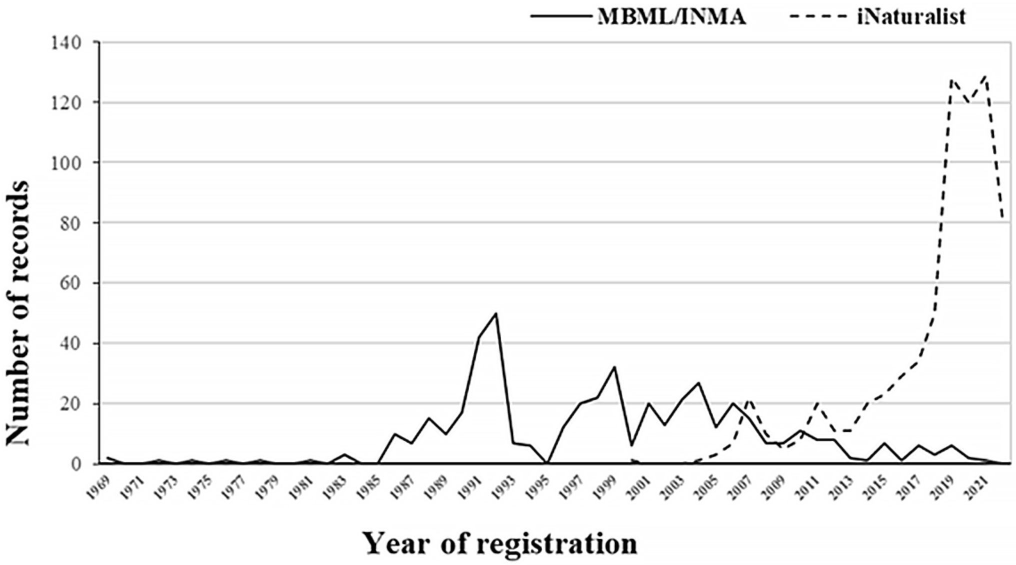

Figure 3. Annual records of reptile specimens (total n = 1,215) by collaborating citizens for the state of Espírito Santo, Brazil based on the Museu de Biologia Professor Mello Leitão – MBML/INMA (solid line) for specimens of reptiles collected, donated, and listed in the zoological collection from 1969 to 2022 (n = 502) and from iNaturalist (dashed line) of reptile specimens photographed and registered on the online platform from 2000 to 2022 (n = 713).

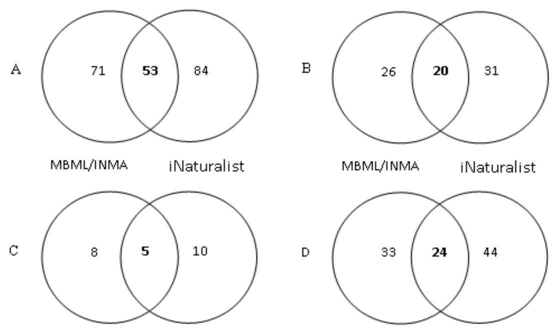

Figure 4. Numbers of unique and shared records (in bold) between Museu de Biologia Professor Mello Leitão - MBML/INMA (1969 to 2022) and iNaturalist platform (2000 to 2022) data on reptiles from the state of Espírito Santo, Brazil, considering: (A) the number of species recorded, (B) endemic species to the Atlantic Forest, (C) threatened species (IUCN 2018; Fraga et al. 2019), and (D) cities number from the state of Espírito Santo with records of reptiles.

On iNaturalist, we recorded 84 species: 43 snakes, 25 lizards, 12 turtles, three amphisbaenians, and one species of crocodilian (Fig. 2). These records were made by 182 registered observers, and validated by 263 specialists, both from Brazil and abroad (Table 1). Although the snake group had a higher number of recorded species, lizards were more prevalent in terms of the number of specimens. The overall average number of species recorded per year was 3.8 (Table 1). Data contributions on the iNaturalist platform saw a significant increase from 2014 onwards, particularly in 2018. The number of contributions peaked in 2021 before experiencing a decline in 2022 (Fig. 3). The Venn diagrams depict the exclusive and shared records between data sources concerning the number of general species, AF endemics, threatened species (VU, EN, and CR), and cities of occurrence. In all instances, iNaturalist was more prominent (Fig. 4).

Regarding the geographic distribution of reptile records in the state of ES, based on occurrence points and species diversity, we found that the data came from 53 cities. In general, the records are more concentrated from the center to the southern of the state; however, when considering the data sources separately, iNaturalist records are concentrated in four important cluster regions: northeast (inland), central highlands, southeast (coast), and northwest (inland) of the state, whereas MBML/INMA records show a more dispersed distribution throughout the state (Fig. 5). We examined the densities of specimen and species distribution records according to the locality. Notably, there was a corresponding overlap in which the higher the number of specimens found in the main locations (hotspots), the higher the number of species found (Fig. 6).

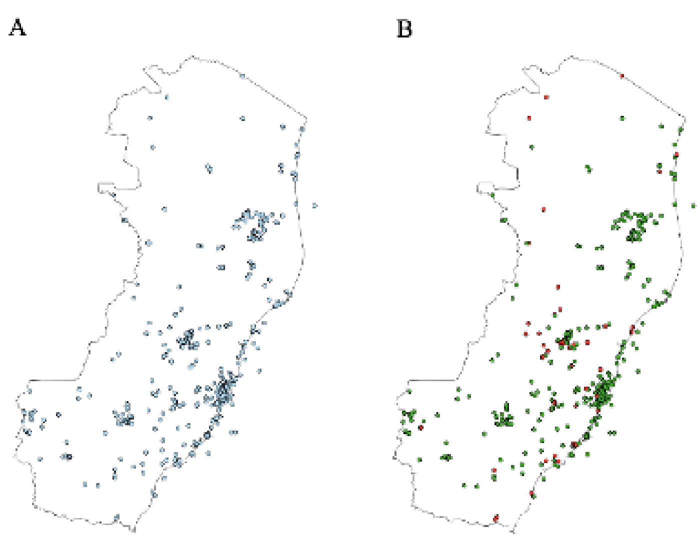

Figure 5. Distribution maps of reptile records from the state of Espírito Santo, Brazil (n = 1,215) for data from Museu de Biologia Professor Mello Leitão - MBML/INMA (1969 to 2022) and the iNaturalist platform (2000 to 2022). (A) Map with location of records of specimens, considering both sources and (B) map with location of reptile records according to source (green – iNaturalist; red – MBML/INMA). See Appendix Table for details on the cities with records.

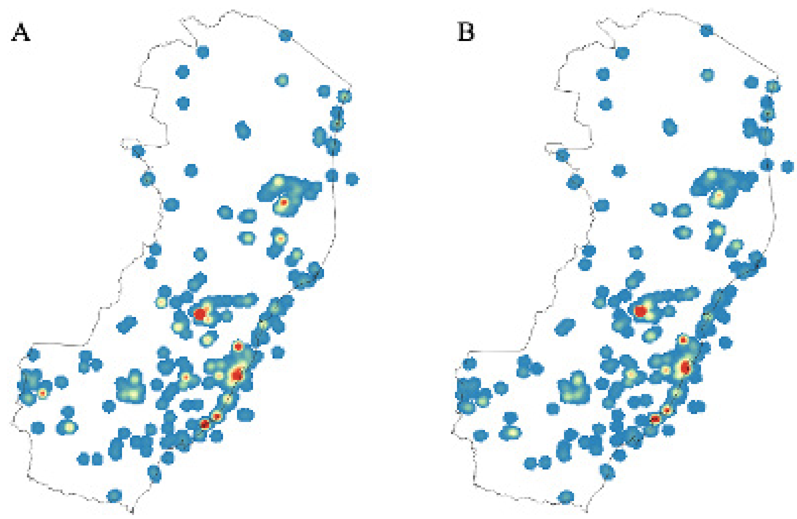

Figure 6. The state of Espírito Santo, Brazil, with Kernel Density Estimates of (A) specimens of reptiles recorded by locality (total n = 1,215 specimens) and (B) species of reptiles recorded by locality (n = 102 species). Yellow and red designate more records than green and blue colors. Data are from Museu de Biologia Professor Mello Leitão - MBML/ INMA (1969 to 2022) and the iNaturalist platform (2000 to 2022).

Discussion

The combined records from MBML/INMA and iNaturalist totaled 102 reptile species, 76.1% of the known diversity of the 134 species known to occur in ES (www.herpetocapixaba.com.br/herpetofauna-capixaba). As expected, the most commonly found and recorded species (*B. jararaca, T. torquatus,* and *S. merianae*) are medium to large generalists with wide distributions (not limited to the Atlantic Forest). These species are either involved in antagonistic interactions with humans (*B. jararaca*) or used by the local population (*S. merianae*) and are not at risk of extinction. The data encompassed 53 (68%) of the 78 municipalities in ES (Appendix Table).

We recorded 37 endemic species of the AF, according to Costa and Bérnils (2018), representing 36.3% of the observed richness, with two species being exclusive to ES (see Fraga et al. 2019). Thirteen species (12.7% of the observed richness) are classified as threatened to some degree and six are considered Data Deficient by IUCN (2018) and local red lists (see Fraga et al. 2019). Additionally, we have documented the probable first occurrence of the snake *Chironius cf. flavolineatus* in the state, but unfortunately the vouchers are missing from the museum. In this study, we also highlight a new occurrence of the snake *Dipsas mikanii* (no common name) in the municipality of Alto Rio Novo, which was recently discovered in two other municipalities in ES (see Castro et al. 2020).

The number of snake species predominated, both separately and in combination in the samples (MBML/INMA + iNaturalist), followed by the number of lizards. Although global lizard diversity is the highest among reptiles, in the tropics, snakes are more diverse (https://www.reptile-database.org), especially in forested areas. In Brazil, 292 lizard species and 430 snake species have been identified so far (Costa and Bérnils 2021).

Snakes play an important ecological role in trophic interactions (Lima-Verde 1994) as prey/predator, and venomous species also have medical importance, e.g., Elapidae and Viperidae (Moura et al. 2010). We know, however, that snakes are more feared than respected for their ecological role due to the fear people have of venom-injecting fangs in viperid (*Bothrops* spp.) and elapid (*Micrurus* spp.) species. Thus, there is a popular fear about these animals and a historical cultural practice of conflicts between humans and snakes (Alves et al. 2012), leading to the extermination of populations and species in many Brazilian regions, particularly in rural perimeters, near natural habitats, and anthropized areas where the chances of encountering snakes are higher.

Our study highlights the importance of considering samples from different sources, demonstrating how complementing data from both can aid in biological citizen science projects. For example, 52% of the richness of species was shared between sources (MBML/INMA and iNaturalist), while the remaining 48% were exclusive contributions from either source. A scientific institution such as MBML/INMA, considered a reference to the country over a long period (53 y), may present an interesting dataset that reflects the diversity and regional characteristics, both in richness and frequency of specimens/group found (in this case, snakes), through observations of non-specialist contributors. From the beginning of the records, the so-called golden periods of reptile contributions to MBML/INMA by the public were mainly concentrated in the 1990s and, secondarily, in the mid-2000s, probably justified by research activities and advertisements directed at the community to donate dead animals people found to the museum. After these periods, contributions steadily declined from 2010 onwards, without significant recoveries. The sharp declines in 2020, 2021, and 2022 can likely be attributed to the coronavirus pandemic, which resulted in social isolation and the suspension of public museum activities.

It is also worth highlighting that the contribution of donations from non-specialists to MBML/INMA, considering the entire reptile collection for the state, represents around 11% of its data. Notably, museum collections are critical for contemporary biological research, and museum acquisitions have decreased in recent decades, hindering the ability of researchers to use collections to assess species responses to habitat modification, urbanization, and climate change (Spear et al. 2017 and their references). Therefore, citizen science may be key to reinforcing crucial data historically housed in museum collections and serves as an effective strategy for obtaining data in urban regions, where understanding ecosystem dynamics is particularly challenging (Spear et al. 2017).

In recent decades there has been a rapid growth in public participation in scientific processes (Kullenberg and Kasperowski 2016; Frigerio et al. 2018), promoting numerous opportunities for scientists and citizens to collaborate for mutual benefit (European Citizen Science Association (ECSA) 2015. Ten Principles of Citizen Science. Available from http://doi.org/10.17605/OSF.IO/XPR2N; Ceccaroni and Piera 2017). Therefore, the use of remote collaborative web-based platforms, such as iNaturalist, offers the advantage of quickly recording species information, both qualitatively and quantitatively, forming a large dataset of biological samples (even during a pandemic).

Although iNaturalist has been in operation for only 22 y and involves fewer collaborators than the museum (i.e., 182 iNaturalist collaborators vs. 315 museum collaborators), its records represent a greater diversity, a higher number of specimens, and more cities than MBML/INMA over five decades. It is important to note that while there has been a consistent and significant decline in annual contributions to MBML/INMA since 2010, contributions to the iNaturalist platform have markedly increased starting in 2014. This underscores the value of using both sources, as the diversity of recorded species has expanded due to each source providing distinct data sets. Over time, the average number of species records per year on iNaturalist was almost three times higher (3.8 species/year) compared to specimens donated by non-specialists to MBML/INMA (1.3 species/year). The records of MBML/INMA show a more dispersed distribution throughout the state, whereas the records of the iNaturalist dataset were more concentratedly distributed, especially in large urban centers and/or typical research areas, such as protected areas and public parks open to population visitation. In a similar CS study involving reptiles and amphibians from Southern California, USA, hosted on the iNaturalist platform for VertNet data (www.vertnet.org), most records were collected in suburban or other highly modified areas, demonstrating the value of CS for collecting data in urban and suburban ecosystems (Spear et al. 2017).

In our study, generalist synanthropic species were emphasized, including lizards (*H. mabouia, T. torquatus, and S. merianae*). These species typically reside within and around the urban centers of Greater Vitória, ES, encompassing the municipalities of Serra, Vila Velha, Cariacica, Viana, Fundão, Guarapari, and Vitória. Snakes were the most diversified group in the study. Data from iNaturalist showcased a broader variety in highlighting the main species or groups recorded, notably, two lizard species and one turtle species stood out among the observations. With the participation and engagement of citizens in data collection, both in person (MBML/INMA) and virtually (iNaturalist), we highlight potential pathways for research projects between scientists and the public.

Zoological collections are important research centers, and public participation in data collection can be relevant for filling information gaps about local/regional diversity. Citizen Science may be key to reinforcing museum collections, particularly in urban regions, where continuous data collection is essential for our understanding of ecosystem dynamics in a highly modified and variable landscape

(Spear et al. 2017). Conversely, since the inception of the project and the adoption of iNaturalist, it has quickly demonstrated its efficacy as a tool for gathering crucial data on the herpetofauna of the state of ES, facilitated by citizen collaboration. Thus, CS can quickly provide data on species and their distributions, particularly valuable as traditional specimen collection has diminished (Spear et al. 2017).

It is important to highlight that the project *Eu conheço os répteis daqui!* was coordinated by a researcher based at INMA. The existence of both a museum and a citizen science initiative hosted at the same research institution highlights the great potential that a scientific infrastructure can promote the study of Brazilian biodiversity, with public participation. This was only possible due to the support from the MCTI/PCI - Brazilian government. The research infrastructure provided by INMA meets what was discussed at the I Workshop of the Brazilian Citizen Science Network (in 2021), in which the need for inter and transdisciplinary research infrastructure for the advancement of CS in Brazil was emphasized (Queiroz-Souza et al. 2023).

Our findings highlight that citizen science is relevant in contributing high-quality data that evidences reptile diversity, distribution, and species conservation status in the state of ES and, therefore, we emphasize that it should be encouraged in other Brazilian scientific institutions distributed across the country. The combination of two different sources of data, MBML/INMA and iNaturalist, encompassing more than five decades, has been crucial for uncovering a significant fraction of the reptile biodiversity known for the state, including endemic species of the AF, species at some degree of risk, and one possible first occurrences of species. Our study contributes to the improvement of both datasets in the future, while also harnessing the potential of citizen science for biodiversity knowledge production in Brazilian research institutions.

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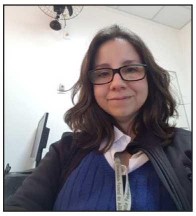

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Appendix

Appendix Table. The state of Espírito Santo with records of reptiles, considering two data sources: Museu de Biologia Professor Mello Leitão – MBML/INMA (from 1969 to 2022) and iNaturalist (from 2000 to 2022).

City	Coordinates
Afonso Cláudio	20°4′27″ S, 41°7′26″ W
Águia Branca	18°58′58″ S, 40°44′24″ W
Alegre	20°45′50″ S, 41°31′58″ W
Alfredo Chaves	20°37′60″ S, 40°45′0″ W
Anchieta	20°48′20″ S, 40°38′40″ W
Alto Rio Novo	19°3′21″ S, 41°1′1″ W
Aracruz	19°49′12″ S, 40°16′22″ W
Baixo Guandu	19°31′8″ S, 41°0′57″ W
Barra de São Francisco	18°45′18″ S, 40°53′27″ W
Cachoeiro de Itapemirim	20°50′56″ S, 41°6′46″ W
Cariacica	20°15′37″ S, 40°25′40″ W
Castelo	20°36′14″ S, 41°11′6″ W
Colatina	19°32′22″ S, 40°37′50″ W
Conceição da Barra	18°35′34″ S, 39°43′55″ W
Conceição do Castelo	20°21′23″ S, 41°14′39″ W
Divino de São Lourenço	20°37′12″ S, 41°41′9″ W
Domingos Martins	20°21′46″ S, 40°39′32″ W
Dores do Rio Preto	20°41′37″ S, 41°50′27″ W
Ecoporanga	18°22′13.19″ S, 40°49′30.59″ W
Fundão	19°55′58″ S, 40°24′25″ W
Governador Lindenberg	19°15′0″ S, 40°27′36″ W
Guaçuí	20°46′34″ S, 41°40′33″ W
Guarapari	20°39′0″ S, 40°30′0″ W
Ibitirama	20°32′27″ S, 41°40′1″ W
Iconha	20°47′34″ S, 40°48′39″ W
Itaguaçu	19°48′7″ S, 40°51′20″ W
Itapemirim	21°0′40″ S, 40°50′2″ W
Itarana	19°52′26″ S, 40°52′30″ W
Iúna	20°20′45″ S, 41°32′9″ W
Linhares	19°23′22″ S, 40°4′4″ W
Mantenópolis	18°51′46″ S, 41°7′22″ W
Marataízes	21°2′34″ S, 40°49′26″ W
Marechal Floriano	20°24′46″ S, 40°40′58″ W
Muniz Freire	20°27′50″ S, 41°24′46″ W
Muqui	20°57′7″ S, 41°20′45″ W
Nova Venécia	18°42′39″ S, 40°24′3″ W
Pancas	19°13′30″ S, 40°51′3″ W

Appendix Table, Continued

City	Coordinates
Pedro Canário	18°18′0″ S, 39°57′0″ W
Pinheiros	18°18′0″ S, 39°57′0″ W
Presidente Kennedy	21°5′56″ S, 41°2′48″ W
Rio Bananal	19°15′54″ S, 40°20′0″ W
Rio Novo do Sul	20°51′46″ S, 40°56′9″ W
Santa Leopoldina	20°6′2″ S, 40°31′47″ W
Santa Maria de Jetibá	20°2′27″ S, 40°44′45″ W
Santa Teresa	19°56′10″ S, 40°36′0″ W
São Mateus	18°43′13″ S, 39°51′19″ W
São Roque do Canaã	19°44′20″ S, 40°39′25″ W
Serra	20°7′43″ S, 40°18′28″ W
Sooretama	19°4′46″ S, 40°1′32″ W
Vargem Alta	20°40′15″ S, 41°0′25″ W
Viana	20°23′24″ S, 40°21′45″ W
Vila Velha	20°19′47″ S, 40°17′33″ W
Vitória	20°19′10″ S, 40°20′17″ W