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ANIMAL SCIENCE

Extensive sampling and citizen science expand the distribution of the threatened freshwater turtle *Ranacephala hogei* (Mertens, 1967)

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Abstract: *Ranacephala hogei* is a South American freshwater turtle considered one of the 25 most endangered chelonian species in the world. Endemic to the Atlantic Forest hotspot of southeastern Brazil, the conservation status of *R. hogei* is subject to continuous assessment at various levels. However, the scarcity of data regarding this species, particularly its geographic range, challenges these evaluations. In an effort to address these gaps, we conducted a comprehensive long-term inventory using different methods to study this species. Our efforts resulted in a 144% increase in documented occurrence points, including a new hydrographic basin and protected areas. By combining historical and current records, we have observed the persistence of *R. hogei* in rural areas, even in locations where its extinction was previously predicted. Consequently, our data significantly contribute to supporting future conservation assessments.

Key words: Atlantic Forest, Chelidae, community science, conservation, geographic range, Testudines.

INTRODUCTION

Geographical distribution data play a vital role in the effective management of threatened species (Saunders et al. 2018). This information is the baseline for various studies in evolution, biogeography, and conservation (Joger et al. 2007, Stuckas et al. 2014, Šarić et al. 2023), supporting assessments of their threat categories (IUCN 2012). This kind of data is particularly crucial today, given the current estimation of extinction rates being 100-1000 times higher than in the past (Lamkin & Miller 2016). Despite advancements, there remains a significant lack of comprehensive knowledge about global, regional, and even local distributions of many species, the 'Wallacean shortfall' (Hortal et al. 2015).

The Wallacean shortfall is essentially alarming for turtles (Testudines), where many species, including critically endangered ones, lack adequate distribution data (Praschag & Singh 2019, Stanford et al. 2020, Fong et al. 2021, Drummond et al. 2022). Furthermore, their long lifespan, delayed sexual maturity, and susceptibility to human activities heighten the impact on this group (Brooks et al. 1991, Enneson & Litzgus 2009, Spencer et al. 2017). Notably, nearly 60% of the roughly 350 modern turtle species face threats or have become extinct (Rhodin et al. 2018). Consequently, turtles are a primary focus in numerous conservation studies, constantly requiring geographic distribution data (Roll et al. 2017, Ennen et al. 2020). Therefore, the success of efforts to reverse declines heavily

relies on the quantity and quality of available species distribution data (Whittaker et al. 2005).

One such species, Hoge's Side-necked Turtle, *Ranacephala hogei* (Mertens 1967), is a rare South American Chelidae endemic to the Atlantic Forest hotspot (TCC 2018, TTWG 2021, Drummond et al. 2022). It inhabits three coastal rivers in southeastern Brazil, with most records found in the Paraiba do Sul River basin, an area significantly impacted by human actions (Polaz 2011, TTWG 2021). This freshwater turtle remains poorly studied, and efforts to increase knowledge about its distribution are limited and dispersed (Mittermeier et al. 1980, Rhodin et al. 1982, Melo & Bruno 2016). *Ranacephala hogei* is prominently featured in conservation efforts at different levels. At the regional level, it is listed as Vulnerable, Endangered, and Critically Endangered in the states of Rio de Janeiro, Minas Gerais, and Espírito Santo, respectively (Bergallo et al. 2000, COPAM 2010, Fraga et al. 2019). Additionally, it is part of the National Action Plan for the Conservation of Endangered Aquatic Species in the Paraíba do Sul River Basin (Polaz et al. 2011). On a larger scale, *R. hogei* has been earmarked as a priority species for captive breeding in Brazil (AZAB 2018), and is listed among the 25 most endangered turtle species worldwide (TCC 2018).

Recently, the conservation status of *R. hogei* was reassessed at national and global levels, resulting in contrasting outcomes. In the Brazilian Red List, the species is labeled as Vulnerable, based on its area of occupancy (MMA 2022, Vogt et al. 2023), while the IUCN Red List categorizes it as Critically Endangered due to the decline in a single population (Drummond et al. 2022). Both assessments lack robust distribution data due to incomplete information about the species geographic range and population monitoring within its habitat.

Therefore, we aim to gather information about this imperiled species and aid in planning effective conservation actions, by: i) investigating whether the distribution of *R. hoge*i is confined solely to the river basins cited in the literature; ii) observing whether the species is rare across its range.

MATERIALS AND METHODS

Study sites

Our study area covered the middle and lower sections of the Paraíba do Sul and Itabapoana river basins, as well as the Lagoa Feia and São João river microbasins, in southeastern Brazil. The predominant climates (Köppen system) are Cwa (humid subtropical with dry winters and hot summers) and Aw (tropical with dry winters), with average annual temperatures of 21-25° C respectively, and annual precipitation ranging from 1000-1600 mm (Alvares et al. 2013). This region is within the Atlantic Forest hotspot (Mittermeier et al. 2004) and is mainly covered by Seasonal Semideciduous Forest and Dense Ombrophilous Forest (IBGE 2012). However, this area is one of the most densely populated in Brazil (IBGE 2021), leading to extensive landscape alterations dominated by pastures, farmlands, and urban environments (Joly et al. 2014). Similarly, rivers have been heavily impacted by industrial activities, domestic sewage, mineral exploration, and inappropriate land use (Sousa 2004, Polaz et al. 2011, Gomes et al. 2022).

Field sampling

We obtained distribution data for *Ranacephala hogei* using different methods. Field sampling was conducted in 2016, and subsequentially each year from 2018 to 2023 (collection permits SISBIO 55868, 62603 and 72576). Sampling took place across the river basins of the Paraíba do Sul (30 points), Itabapoana (12 points), São João

(8 points), and Lagoa Feia (2 points) (Figures 1 and 2b). Each sampling ranged from one to three nights. We used 5-50 hoop traps (Lagler 1943), installed on the margins of each sampling site. Hoop traps measured 80-100 cm in length and 40-50 cm in height, with two entrances of 25-30 cm diameter, and 2 cm mesh. Bait was composed of a mixture of meat, liver, canned sardines, cat food, and pineapple. The traps were checked daily, primarily in the early morning. The cumulative effort using this method was 125 sampling nights and 1648 trap/nights (Table I). All captured animals were measured, marked, and released at the same capture location, and this data will be addressed in another study.

Literature review

To ascertain documented records of the species, we searched for peer-reviewed publications using the key words "Phrynops hogei" OR "Mesoclemmys hogei" OR "Ranacephala hogei" in Scopus (https://www.scopus.com/), Web of Science (https://www.webofknowledge.com), and Google Scholar (https://scholar.google.com/) databases in January 2024. Additionally, we did a comprehensive review across all issues of the journal Herpetological Review (https://ssarherps.org/publications/herpetological-review/) and the publications from the Chelonian Research Foundation (https://chelonian.org/crf-publications/).

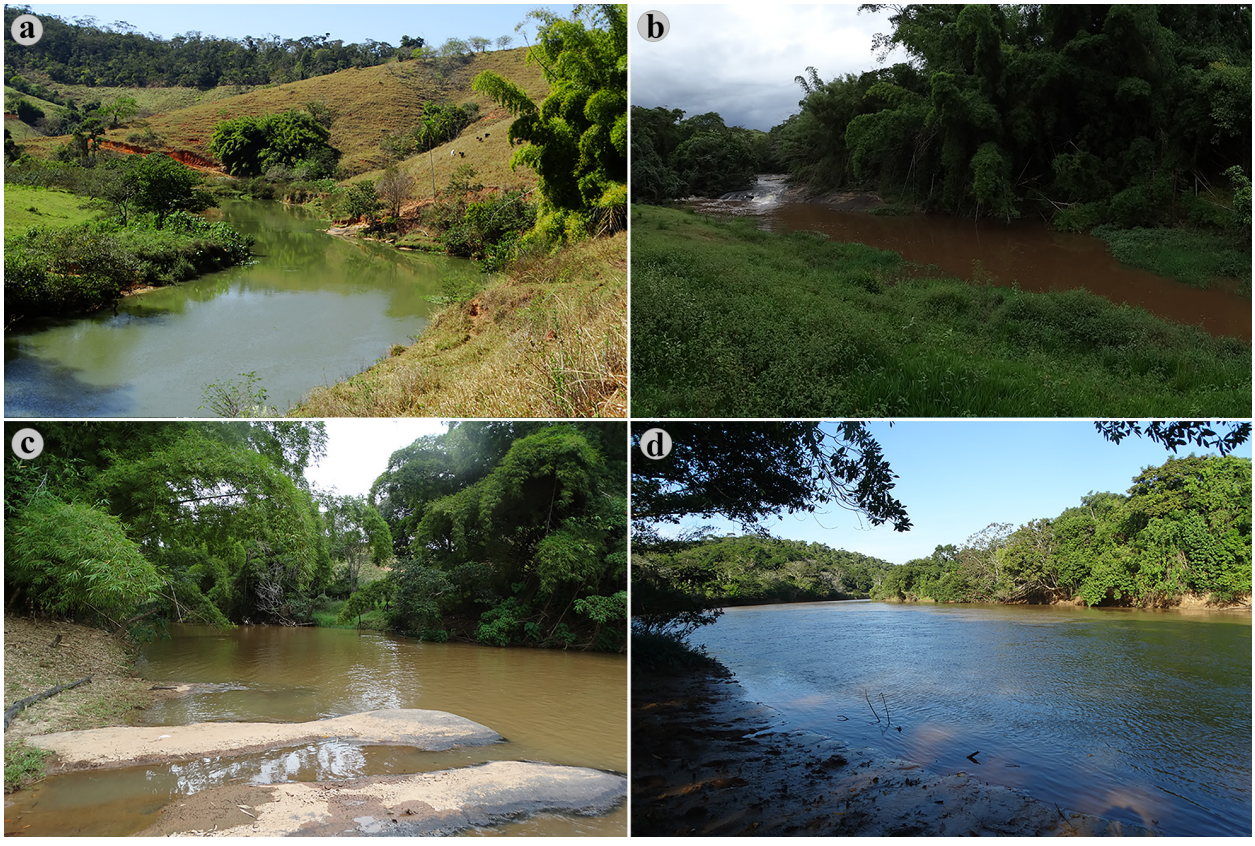

Figure 1. New recording sites of *Ranacephala hogei*. Minas Gerais: (a) Carangola River, Tombos; (b) Monos River, Recreio. Rio de Janeiro: (c) Negro River, Itaocara. Espírito Santo: (d) Itabapoana River, Mimoso do Sul.

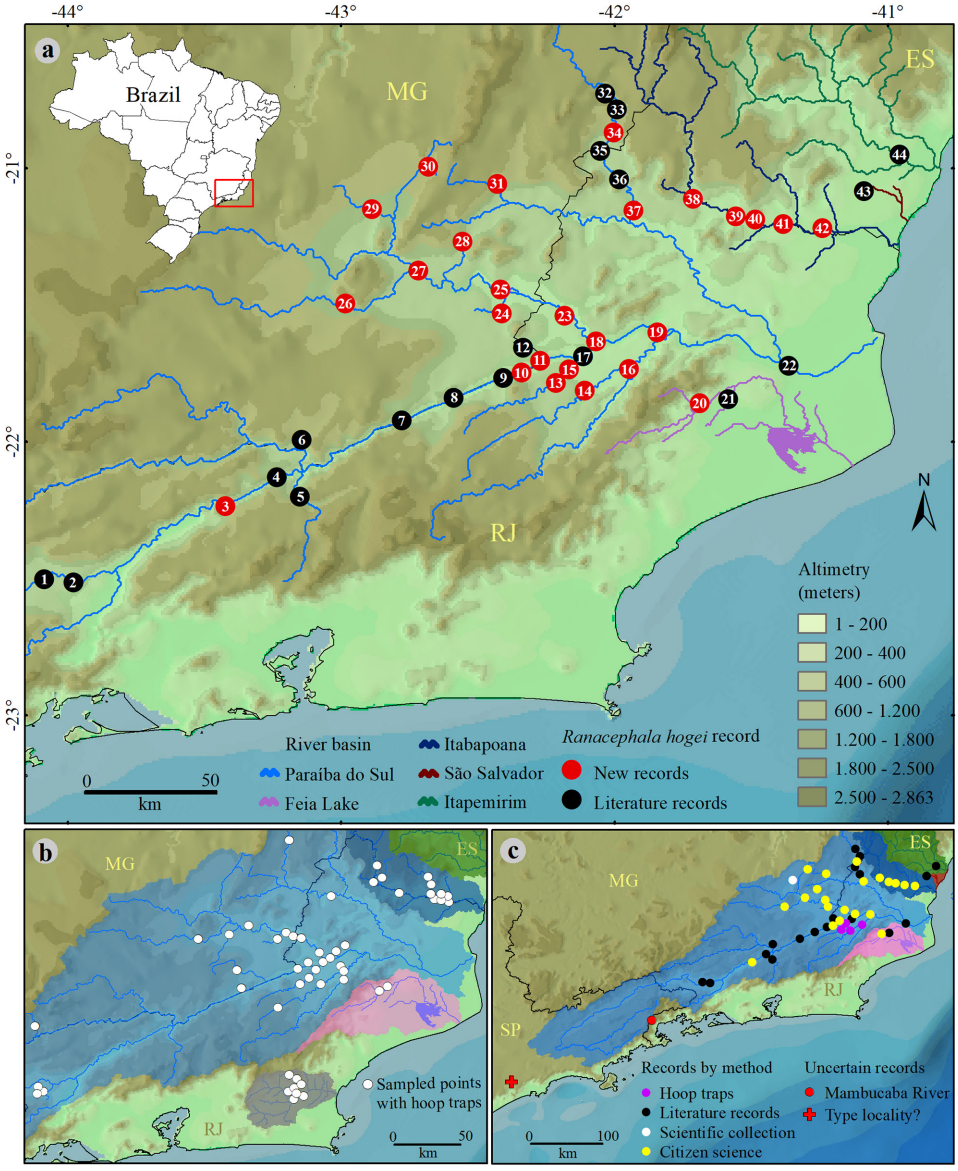

Figure 2. Updated known distribution map of *Ranacephala hogei*. (a) New records and confirmed literature records (locality numbers correspond to Table II). (b) Sampling points with hoop traps. (c) Details of the records by methodology and uncertain records. The river basins in maps b and c correspond to the legend in map a, with the exception of the São João River basin, highlighted in gray in map b. Federative states: MG = Minas Gerais, ES = Espírito Santo, RJ = Rio de Janeiro, SP = São Paulo.

Table I. Details of sampled areas and capture effort in the *Ranacephala hogei* survey. States: MG = Minas Gerais, ES = Espírito Santo, RJ = Rio de Janeiro. River basin: PS = Paraíba do Sul, LF = Lagoa Feia, SJ = São João, ITB = Itabapoana. Datum = WGS 84.

Year	Month	Municipality	State	River basin	Site	Coordinates	Effort in trap-night (tn)
2016	Nov.	Aperibé/Cambuci	RJ	PS	Pomba River	-21.6345 -42.0663	10 traps x 1 night (10 tn)
2016	Nov.	Itaocara/Aperibé	RJ	PS	Paraíba do Sul River	-21.6439 -42.0491	30 traps x 1 night (30 tn)
2016	Nov.	Itaocara	RJ	PS	Lowland swamps	-21.6341 -42.0300	7 traps x 2 night (14 tn)
2016	Nov.	Cambuci	RJ	PS	Small stream	-21.5439 -41.9336	10 traps x 2 night (20 tn)

Table I. Continuation.

Year	Month	Municipality	State	River basin	Site	Coordinates	Effort in trap-night (tn)
2016	Nov.	Pirapetinga/Santo Antônio de Pádua	MG/ RJ	PS	Pirapetinga River	-21.7083 -42.2669	38 traps x 3 night (114 tn)
2016	Nov.	Aperibé/Santo Antônio de Pádua	RJ	PS	Small stream	-21.6799 -42.1857	10 traps x 2 night (20 tn)
2016	Nov.	Itaocara/São Sebastião do Alto	RJ	PS	Negro River	-21.7386 -41.9404	30 traps x 2 night (60 tn)
2016	Nov.	Itaocara	RJ	PS	Lake	-21.7320 -41.9443	10 traps x 2 night (20 tn)
2016	Nov.	Itaperuna	RJ	PS	Muriaé River	-21.1974 -42.0317	40 traps x 2 night (80 tn)
2018	Oct.	Campos dos Goytacazes	RJ	LF	Mocotó River	-21.8663 -41.6911	20 traps x 3 night (60 tn)
2018	Oct.	Campos dos Goytacazes	RJ	LF	Imbé River	-21.8646 -41.6787	20 traps x 3 night (60 tn)
2018	Sept.	Itaocara	RJ	PS	Areias Stream	-21.7131 -42.1419	6 traps x 2 night (12 tn)
2018	Sept.	Itaocara	RJ	PS	Areias Stream	-21.7443 -42.1666	13 traps x 1 night (13 tn)
2018	Oct.	Itaocara/São Sebastião do Alto	RJ	PS	Negro River	-21.8162 -42.1053	30 traps x 1 night (30 tn)
2018	Mar.	Além Paraíba	MG	PS	Angú River	-21.7183 -42.6930	6 traps x 3 night (18 tn)
2018	Aug.	Além Paraíba	MG	PS	Angú River	-21.7183 -42.6930	6 traps x 3 night (18 tn)
2018	Mar.	Além Paraíba	MG	PS	Aventureiro River	-21.8423 -42.6633	6 traps x 3 night (18 tn)
2018	Aug.	Além Paraíba	MG	PS	Aventureiro River	-21.8423 -42.6633	6 traps x 3 night (18 tn)
2018	Mar.	São João Nepomuceno/ Descoberto	MG	PS	Novo River	-21.4985 -42.9661	6 traps x 3 night (18 tn)
2018	Aug.	São João Nepomuceno/ Descoberto	MG	PS	Novo River	-21.4985 -42.9661	6 traps x 3 night (18 tn)
2018	Mar.	Santa Rita do Jacutinga	MG	PS	Jacutinga River	-22.1083 -44.1099	8 traps x 3 night (24 tn)
2018	July	Santa Rita do Jacutinga	MG	PS	Jacutinga River	-22.1083 -44.1099	8 traps x 3 night (24 tn)
2018	July	Recreio	MG	PS	Monos Stream	-21.4985 -42.4089	6 traps x 3 night (18 tn)
2018	Dec.	Recreio	MG	PS	Monos Stream	-21.4985 -42.4089	6 traps x 3 night (18 tn)

Table I. Continuation.

Year	Month	Municipality	State	River basin	Site	Coordinates	Effort in trap-night (tn)
2018	July	Palma	MG	PS	Pomba River	-21.4867 -42.2912	6 traps x 3 night (18 tn)
2018	Dec.	Palma	MG	PS	Pomba River	-21.4867 -42.2912	6 traps x 3 night (18 tn)
2018	Sept.	Casimiro de Abreu/ Silva Jardim	RJ	SJ	Aldeia Velha River	-22.5014 -42.2648	10 traps x 3 night (30 tn)
2018	Sept.	Casimiro de Abreu/ Silva Jardim	RJ	SJ	Aldeia Velha River	-22.5280 -42.2616	10 traps x 3 night (30 tn)
2018	Sept.	Silva Jardim	RJ	SJ	São João River	-22.5796 -42.2896	20 traps x 3 night (60 tn)
2018	Sept.	Silva Jardim	RJ	SJ	Lake	-22.5366 -42.2633	5 traps x 1 night (5 tn)
2018	Sept.	Casimiro de Abreu/ Silva Jardim	RJ	SJ	Aldeia Velha River	-22.5281 -42.2607	5 traps x 2 night (10 tn)
2018	Sept.	Silva Jardim	RJ	SJ	Lake/ Lowland swamps	-22.5806 -42.2743	17 traps x 2 night (34 tn)
2018	Sept.	Silva Jardim	RJ	SJ	São João River	-22.5790 -42.2778	6 traps x 2 night (12 tn)
2018	Sept.	Silva Jardim	RJ	SJ	São João River	-22.5621 -42.2723	5 traps x 1 night (5 tn)
2019	Oct.	Itaocara	RJ	PS	Areias Stream	-21.7357 -42.1602	20 traps x 2 night (40 tn)
2019	Oct.	Volta Redonda	RJ	PS	Brandão River	-22.5596 -44.0863	21 traps x 2 night (42 tn)
2019	Oct.	Volta Redonda	RJ	PS	Lake	-22.5484 -44.0784	13 traps x 2 night (26 tn)
2019	Oct.	Volta Redonda	RJ	PS	Brandão River	-22.5598 -44.0869	9 traps x 1 night (9 tn)
2019	July	São Francisco do Glória	MG	PS	Glória River	-20.8065 -42.3265	6 traps x 3 night (18 tn)
2019	Oct.	São Francisco do Glória	MG	PS	Glória River	-20.8065 -42.3265	6 traps x 3 night (18 tn)
2019	June	Santo Antônio de Pádua	MG	PS	Pomba River	-21.4926 -42.2407	6 traps x 3 night (18 tn)
2019	Dec.	Santo Antônio de Pádua	MG	PS	Pomba River	-21.4926 -42.2407	6 traps x 3 night (18 tn)
2020	Nov.	Cataguases/ Leopoldina	MG	PS	Pardo River	-21.4366 -42.6721	17 traps x 1 night (17 tn)
2020	Nov.	Cataguases	MG	PS	Lake	-21.4344 -42.6785	7 traps x 1 night (7 tn)

Table I. Continuation.

Year	Month	Municipality	State	River basin	Site	Coordinates	Effort in trap-night (tn)
2020	Nov.	Cataguases	MG	PS	Cágado Stream	-21.4028 -42.6122	17 traps x 1 night (17 tn)
2020	Jan.	São Francisco do Glória	MG	PS	Glória River	-20.8065 -42.3265	6 traps x 3 night (18 tn)
2021	Oct.	Itaocara	RJ	PS	Paraiba do Sul River	-21.6381 -42.0316	8 traps x 2 night (16 tn)
2022	May	São José dos Calçados/Bom Jesus do Norte	ES	ITB	Calçado River	-21.1041 -41.7179	9 traps x 2 night (18 tn)
2022	May	Bom Jesus do Itabapoana/Bom Jesus do Norte	RJ/ ES	ITB	Itabapoana River	-21.1130 -41.7127	21 traps x 2 night (42 tn)
2022	May	Bom Jesus do Itabapoana/São José dos Calçados	RJ/ ES	ITB	Itabapoana River	-21.0313 -41.7257	20 traps x 2 night (40 tn)
2022	May	Bom Jesus do Itabapoana/Mimoso do Sul	RJ/ ES	ITB	Itabapoana River	-21.1776 -41.5556	50 traps x 2 night (100 tn)
2022	Apr.	Itaocara	RJ	PS	Lake	-21.7325 -41.9437	3 traps x 1 night (3 tn)
2022	May	Cantagalo	RJ	PS	Negro River	-21.9788 -42.4056	20 traps x 1 night (20 tn)
2023	May	Mimoso do Sul/ Campos dos Goytacazes	ES/ RJ	ITB	Itabapoana River	-21.2217 -41.3086	20 traps x 2 night (40 tn)
2023	May	Mimoso do Sul	ES	ITB	Muqui do Sul River	-21.1814 -41.3351	20 traps x 2 night (40 tn)
2023	May	Mimoso do Sul	ES	ITB	Lowland swamps	-21.1808 -41.3362	10 traps x 1 night (10 tn)
2023	May	Mimoso do Sul	ES	ITB	Muqui do Sul River	-21.0889 -41.3442	20 traps x 3 night (60 tn)
2023	May	Mimoso do Sul/ São Francisco do Itabapoana	ES/ RJ	ITB	Itabapoana River	-21.2254 -41.2330	23 traps x 1 night (23 tn)
2023	May	Mimoso do Sul	ES	ITB	Drainage channel	-21.2243 -41.2325	14 traps x 1 night (14 tn)
2023	May	Mimoso do Sul	ES	ITB	Lowland swamps	-21.2244 -41.2330	9 traps x 1 night (9 tn)
2023	May	Mimoso do Sul	ES	ITB	Lowland swamps	-21.2198 -41.2326	8 traps x 1 night (8 tn)

Scientific collections

We examined specimens from the following natural history collections in Brazil: Museu de Zoologia João Moojen, Universidade Federal de Viçosa, Viçosa, Minas Gerais, (MZUFV); Museu de Zoologia Newton Baião de Azevedo, Universidade do Estado de Minas Gerais, Carangola, Minas Gerais, (MZNB); Coleção de Répteis do Centro de Coleções Taxonômicas da Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil (UFMG-REP); Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, (MNRJ), Museu de Zoologia da Universidade de São Paulo, São Paulo, (MZUSP), and Museu de Zoologia da Universidade Estadual de Campinas (ZUEC-REP).

Citizen science

During fieldwork, we collected data through citizen science, with volunteers assisting in data collection (Cohn 2008), a method widely used in biological monitoring (Cunha et al. 2017). Engagements were made with fishermen, local residents, environmental police, and other researchers operating in our study areas. We explained the objectives of our study, showing images of *R. hogei*, and left contact details (cellphone number) for communication in case of potential sightings of the species. We treated citizen science records as incidental observations, as we did not recommend specific efforts toward capturing the turtles. We only included records that allowed unequivocal species identification (supported by photographic evidence) and provided the precise location of the record.

Presence in protected areas

To confirm the presence of *R. hogei* in protected areas, we plotted records using Arcmap (v.10.8 ESRI) against a map displaying Brazil's protected areas, (CNUC 2023). We consider protected areas as territorial spaces with significant natural characteristics wherein protection guarantees are applied based on the National System of Nature Conservation Units (Brasil 2000).

RESULTS

During our field samplings, we successfully captured 24 specimens of *R. hogei* in four previously unrecorded localities. Our bibliographic review contributed with 20 occurrence points for this freshwater turtle species, two of these (type locality in São Paulo and the Mambucaba River micro-basin in Paraty, Rio de Janeiro) are uncertain (Figure 2c). Consulting with curators and examining specimens in collections revealed an additional locality for the species. Citizen science efforts provided evidence of 49 specimens from 21 new localities, expanding our geographic reach to areas not sampled by our team (Figure 2c). Notably, four protected areas have records of *R. hogei*: "Refúgio de Vida Silvestre Estadual do Médio Paraíba" and "Área de Proteção Ambiental do Triunfo" in the state of Rio de Janeiro; "Estação Ecológica de Água Limpa" in the state of Minas Gerais; and "Área de Proteção Ambiental Guanandy", in the state of Espírito Santo.

Collectively, these combined efforts resulted in 44 confirmed occurrence points for *R. hogei*, 26 of these being new records (Figure 3). These confirmed occurrences are distributed across the Brazilian states of Minas Gerais, Rio de Janeiro, and Espírito Santo, spanning five hydrographic basins: Paraíba do Sul River (n=35), Itabapoana River (n=5), Itapemirim River (n=1), São Salvador Stream (1), and Lagoa Feia (n=2) (Table II). Regarding the new records, most (80%) were observed in the Paraíba do Sul River basin, primarily in small tributaries close to the main river and within the sub-basins of the Pomba and Muriaé rivers inland. The elevation of these documented points ranged from four

Figure 3. Specimens of *Ranacephala hogei* recorded during our study. Rio de Janeiro/Espírito Santo: (a) juvenile male from the Itabapoana River, Bom Jesus do Itabapoana/Mimoso do Sul. Rio de Janeiro: (b) adult male from the Negro River, Itaocara/São Sebastião do Alto. Minas Gerais: (c) juvenile (indeterminate sex) from the Pomba River, Cataguases; (d) adult male from the Carangola River, Tombos; (e) adult female from the Pomba River, Laranjal/Recreio; (f) juvenile male from the Monos River, Recreio.

(Itapemirim river), to 400 meters above sea level (Carangola river), with an average of 162 meters (± 123).

DISCUSSION

Here, we present a comprehensive study using various methods to update the known geographic distribution of the threatened freshwater turtle *Ranacephala hogei*. Compared to the available literature, our efforts increased the occurrence points of this species by 144%. Notably, our research extended the known range of *R. hogei* westward in the state of Minas Gerais, documenting the species in the headwaters of the Pomba River and the Muriaé River sub-basin, both tributaries of the Paraíba do Sul River. Of particular interest are points 29 and 30 (Figure 2a) in the tributaries of the Pomba River, approximately 176 km from the coast, the most inland records for *R. hogei*. Equally important is the discovery of five *R. hogei* specimens in the Itabapoana River (Figure 2a, points 38 to 42), respectively 23 and 21 km from the nearest records in the Paraíba do Sul River and São Salvador Stream basins. This finding adds a new hydrographic basin (Itabapoana River) where *R. hogei* occurs.

Two records of *R. hogei* are considered uncertain (TTWG 2021) and have been omitted from our distribution map (Figure 2c). The first is the type locality at "Rio Pequeno", a small

Table II. Distribution records of *Ranacephala hogei*. States: MG = Minas Gerais, ES = Espírito Santo, RJ = Rio de Janeiro. River basin: PS = Paraíba do Sul, LF = Lagoa Feia, ITB = Itabapoana, SS = São Salvador, ITP = Itapemirim. Source: 1 = Mittermeier et al. (1980), 2 = Rhodin et al. (1982), 3 = TTWG (2021), 4 = Gomes et al. (2023). Datum = WGS 84.

Map point	Municipality	State	River basin	Site	Coordinates	Elev. (meters)	Registration method	Source
1	Volta Redonda	RJ	PS	Paraíba do Sul River	-22.5029 -44.0860	370	–	3
2	Pinheiral/ Barra do Piraí	RJ	PS	Paraíba do Sul River	-22.5156 -43.9791	362	–	1, 2, 3
3	Vassouras	RJ	PS	Paraíba do Sul River	-22.2365 -43.4230	292	Citizen science. 1 captured by a local resident.	New record
4	Três Rios	RJ	PS	Paraíba do Sul River	-22.1302 -43.2350	275	–	1, 2, 3
5	Areal	RJ	PS	Preto River	-22.2016 -43.1505	332		4
6	Chiador/Santana do Deserto	MG	PS	Cágado River	-21.9941 -43.1438	299	–	3
7	Além Paraíba/ Sapucaia	MG/RJ	PS	Paraíba do Sul River	-21.9224 -42.7781	143	–	1, 2, 3
8	Volta Grande/ Carmo	MG/RJ	PS	Paraíba do Sul River	-21.8372 -42.5817	103	–	3
9	Estrela Dalva/ Cantagalo	MG/RJ	PS	Paraíba do Sul River	-21.7624 -42.3992	93	–	3
10	Pirapetinga/ Canta Galo	MG/RJ	PS	Paraíba do Sul River	-21.7481 -42.3393	85	Citizen science. 1 captured by a local fisherman.	New record
11	Pirapetinga/ Santo Antônio de Pádua	MG/RJ	PS	Pirapetinga River	-21.7045 -42.2713	81	Citizen science. 1 visualized by a researcher.	New record
12	Pirapetinga/ Santo Antônio de Pádua	MG/RJ	PS	Pirapetinga River	-21.6914 -42.2659	94	–	3
13	Itaocara	RJ	PS	Areias Stream	-21.7441 -42.1664	75	Freshwater turtle surveys. 3 captured by hoop-net trap.	New record
14	Itaocara/São Sebastião do Alto	RJ	PS	Negro River	-21.8144 -42.1074	108	Freshwater turtle surveys. 1 captured by hoop-net trap.	New record

Table II. Continuation.

Map point	Municipality	State	River basin	Site	Coordinates	Elev. (meters)	Registration method	Source
15	Itaocara	RJ	PS	Areias Stream	-21.7127 -42.1437	75	Freshwater turtle surveys. 1 captured by hoop-net trap.	New record
16	Itaocara/São Sebastião do Alto	RJ	PS	Negro River	-21.7347 -41.9464	60	Freshwater turtle surveys. 19 captured by hoop-net trap.	New record
17	Itaocara/Aperibé	RJ	PS	Paraíba do Sul River	-21.6885 -42.1142	60	–	3
18	Aperibé/Cambuci	RJ	PS	Pomba River	-21.6346 -42.0666	57	Citizen science. 1 captured by a researcher.	New record
19	São Fidelis	RJ	PS	Paraíba do Sul River	-21.6002 -41.8424	30	Citizen science. 1 captured by a local fisherman.	New record
20	Campos dos Goitacazes	RJ	LF	Mocotó River	-21.8601 -41.6873	15	Citizen science. 1 captured by a researcher.	New record
21	Campos dos Goytacazes	RJ	LF	Urubú River	-21.8451 -41.5833	9	–	3
22	Campos dos Goytacazes	RJ	PS	Paraíba do Sul River	-21.7223 -41.3616	5	–	1, 2, 3
23	Santo Antônio de Pádua	RJ	PS	Pomba River	-21.5403 -42.1820	90	Citizen science. 1 captured by a local fisherman.	New record
24	Recreio	MG	PS	Monos Stream	-21.4985 -42.4089	160	Citizen science. 1 captured by a local fisherman.	New record
25	Laranjal/ Recreio	MG	PS	Pomba River	-21.4444 -42.4159	145	Citizen science. 1 captured by a local fisherman.	New record
26	Descoberto/ São João Nepomuceno	MG	PS	Novo River	-21.4958 -42.9845	340	Citizen science. 1 captured by a local resident.	New record
27	Cataguases	MG	PS	Small tributary of the Pomba River	-21.3748 -42.7171	263	Citizen science. 1 captured by a researcher.	New record
28	Santana de Cataguases	MG	PS	Fumaça Stream	-21.2609 -42.5497	280	Citizen science. 1 collected by the Environmental Police.	New record

Table II. Continuation.

Map point	Municipality	State	River basin	Site	Coordinates	Elev. (meters)	Registration method	Source
29	Ubá	MG	PS	Ubá Stream	-21.1387 -42.8798	300	Deposited in scientific collection (MNRJ 4803)	New record
30	Guiricema	MG	PS	Bagres Stream	-20.9951 -42.6809	349	Citizen science. 1 captured by a local resident.	New record
31	Muriaé	MG	PS	Preto River	-21.0578 -42.4286	230	Citizen science. 1 visualized by a researcher.	New record
32	Carangola	MG	PS	Carangola River	-20.7449 -42.0111	400	–	3
33	Faria Lemos	MG	PS	Carangola River	-20.8224 -42.0126	327	–	3
34	Tombos	MG	PS	Carangola River	-20.8519 -41.9999	324	Citizen science. 28 captured by a local fisherman.	New record
35	Tombos	MG	PS	Carangola River	-20.9165 -42.0338	220	–	3
36	Natividade	RJ	PS	Carangola River	-21.0416 -42.9829	187	–	3
37	Natividade/ Itaperuna	RJ	PS	Carangola River	-21.1561 -41.9297	130	Citizen science. 1 captured by a local fisherman.	New record
38	Bom Jesus do Itabapoana/Bom Jesus do Norte	RJ/ES	ITB	Itabapoana River	-21.1126 -41.7124	111	Citizen science. 1 captured by a researcher.	New record
39	Bom Jesus do Itabapoana/ Mimoso do Sul	RJ/ES	ITB	Itabapoana River	-21.1772 -41.5546	69	Citizen science. 1 captured by a local fisherman.	New record
40	Bom Jesus do Itabapoana/ Mimoso do Sul	RJ/ES	ITB	Itabapoana River	-21.1826 -41.4996	61	Citizen science. 1 captured by a researcher.	New record
41	Campos dos Goitacazes	RJ	ITB	Itabapoana River	-21.2048 -41.3816	62	Citizen science. 1 captured by a local fisherman.	New record
42	Mimoso do Sul	ES	ITB	Lowland swamps	-21.2193 -41.2391	15	Citizen science. 1 captured by a researcher.	New record
43	Presidente Kennedy	ES	SS	?	-21.0850 -41.0863	52	–	1, 3
44	Itapemirim	ES	ITP	Itapemirim River	-20.9507 -40.9562	4	–	1, 3

tributary of the Tietê River, near the municipality of São Paulo (Mertens 1967). Rhodin et al. (1982) questioned the validity of this record due to the uncertain origin of the holotype, that had been kept not tagged in a serpentarium at the Instituto Butantan. Furthermore, "Rio Pequeno" is at an elevation above 500 meters, while the species inhabits areas with an average elevation of 163 meters, and the nearest confirmed record of *R. hogei* is more than 300 km away from this location. The second uncertain record is from Serra do Mar, in the Mambucaba River micro-basin, state of Rio de Janeiro (TTWG 2021), approximately 80 km from the nearest occurrence of *R. hogei* in the Paraíba do Sul River. Despite the proximity, the record from Serra do Mar is at 1180 m elevation. Even though we did not sample these two areas of uncertain records, we support the hypothesis of the absence of *R. hogei* there.

Moreover, we refined the accuracy of the occurrence points of *R. hogei* in the Itapemirim River basin. Three points of occurrence of the species have been recorded in the state of Espírito Santo, two in the Itapemirim river and one further south in the microbasin of the São Salvador Stream (TTWG 2021). However, a discrepancy arose as these records referred to specimens mentioned in Mittermeier et al. (1980) (A.G.J. Rhodin, personal communication). These authors recorded three live specimens near the mouth of the Itapemirim River, two of which were kept at the Ataliba Farm (currently Usina Paineiras, coordinates adjusted by us), east of the BR-101 highway, and one in the region of the São Salvador Stream. The locality plotted by TTWG (2021) at the mouth of the Rio Itapemirim appears to have been erroneously mapped and is not considered here.

In examining historical records, we found evidence of *Ranacephala hogei* persisting in rural landscapes. Specimens collected in 1952 (MZUSP 2683) and 1984 (MNRJ 10058) in the municipality of Pinheiral, and 1990 (ZUEC-REP 1167) in the municipality of Itaocara, all within the Paraíba do Sul River basin, are housed in scientific collections. In Pinheiral, a study conducted in 2015 recorded 30 observations and captured 18 adults and juveniles (Melo & Bruno 2016), while our study in Itaocara resulted in 24 captures of adults and juveniles. This confirms that the species persists in these impacted areas after 63 and 28 years, respectively. Building on this finding, we highlight an intriguing aspect related to a population of *R. hogei* from the Carangola River, a sub-tributary of the Paraíba do Sul River. Prior research in this area suggested an average annual rate of decline rate of 16.2% since 1992, projecting local extinction within less than seven years (Drummond et al. 2022). However, our results revealed casual sightings of 30 specimens (9 juveniles and 21 adults) caught by fishermen between 2021 and 2023 in the same area. This demonstrates that 31 years after the forecasted local extinction, the species not only endures but also reproduces in the area. This resilience might be due to the species adaptability to habitat changes, contrasting with turtles having specialized habitat needs and specific diets, which render them more susceptible to environmental shifts (Burbidge 1981, Regolin et al. 2023). Indeed, the life history of *Ranacephala hogei* remains unknown, but these findings suggest a certain resilience to anthropogenic changes, potentially owing to a broader ecological niche, allowing for greater adaptability in diet, habitat use, and environmental changes (Fachin-Teran et al. 1995, Souza & Abe 2000, Stokeld et al. 2014).

We underscore the critical role of citizen science in updating the distribution range of *R. hogei*, by adding 21 new records (more that any methods used by this study). This method expanded our geographic reach and revealed

records beyond our survey areas, including the most inland records of the species and records within the Itabapoana River, where we extensively sampled (384 traps-night) but had negative results. Citizen science has already provided important data on threatened turtles such as *Macrochelys temminckii* in the United States (Gordon et al. 2023) and *Indotestudo elongata* in Bhutan (Wangyal et al. 2022). However, one particularly impressive case occurred in northern Vietnam, where a field study involving local residents and hunters resulted in the documentation of nine threatened species (Thong et al. 2020, IUCN 2023), with a prevalence of *Cuora galbinifrons*, listed among the 50 most endangered turtle species worldwide (TCC 2018, Thong et al. 2020). Considering the pivotal role of citizen science in studies related to the conservation of endangered turtles (Anadón et al. 2009, Thong et al. 2020, Cross et al. 2021, Gordon et al. 2023), we emphasize the importance of public participation in the future monitoring of *R. hogei*.

The presence of *R. hogei* in protected areas enhances the significance of these locations, given the species' presence in red lists (MMA 2022, Drummond et al. 2022). Of the four protected areas with the species confirmed occurrences, the "Refúgio de Vida Silvestre do Médio Paraíba" is a strictly protected area, corresponding to IUCN category III (Rylands & Brandon 2005). Covering about 111 km^2, it extends along the banks of the Paraiba do Sul River for approximately 186 km in the state of Rio de Janeiro (CNUC 2023). The other protected area with confirmed presence of *R. hogei* is the "Estação Ecológica de Água Limpa", corresponding to IUCN category Ia (Rylands & Brandon 2005). This area consists of a small remnant of native forest with 0.71 km^2, near the Pomba River in the state of Minas Gerais (CNUC 2023). Unlike other protected areas with records of *R. hogei*, which fall into categories with fewer restrictions (IUCN category V), these two areas are under strict protection (Brasil 2000, Rylands & Brandon 2005). Consequently, they contribute more effectively to the preservation of the habitats of this freshwater turtle. However, the effectiveness of this protection could be improved with specific programs and actions tailored to this species. Unfortunately, both protected areas lack management plans (CNUC 2023), crucial for implementing conservation strategies (Thomas & Middleton 2003). Urgent elaboration of these plans is necessary to direct focused actions for the protection of *R. hogei*.

In conclusion, our findings offer optimism regarding the conservation status of *R. hogei*, providing valuable information for future assessments, conservation, and management of this species. The integration of traditional inventory methods with citizen science has revealed a larger distribution range for *R. hogei* than previously assumed, including new hydrographic basins. Moreover, the species might not be as rare as reported in the literature; its perceived rarity may be associated with the absence of specific and extensive sampling efforts. We have also observed that this species survives and reproduces in areas where local extinction was previously predicted. Hence, although the limits of its persistence remain unknown, our findings suggest that, with appropriate conservation efforts, *R. hogei* can thrive in human-dominated rural landscapes. Future research should focus on monitoring the species and investigating gene flow between its habitats. Furthermore, efforts in environmental education should target fishermen and riverside dwellers to underscore the importance of preserving this freshwater turtle.

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