

# Geckos Forasteros: an assessment of the invasion status by exotic geckos in Argentina using citizen science

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Recibido: 24 Junio 2025

Revisado: 22 Septiembre 2025

Aceptado: 27 Octubre 2025

Editor Asociado: S. Quinteros

doi: 10.31017/CdH.2025.(2025-023)

## ABSTRACT

Geckos are among the most successful reptile invaders and have colonized a wide range of suitable habitats and climates around the world. Outside their native range, they usually show a clear association with urban habitats and human-modified habitats. In Argentina, *Hemidactylus mabouia* and *Tarentola mauritanica* had confirmed records for a few provinces. *Hemidactylus turcicus* was reported for Buenos Aires in 1989 from a single record, but later its presence became dubious as it belonged to a misidentified *H. mabouia*. We started a citizen-science project called Geckos Forasteros, to update the invasion status of gecko species in Argentina. We collected records of geckos from online social networks and the project's online form, where people voluntarily sent pictures and information about their findings. Our results confirm the presence of *H. turcicus* in the country and reveal that the extent of the invasion by *T. mauritanica* and *H. mabouia* in the country is far larger than previously thought, including the southernmost records worldwide for the three species. We explored the environmental variables associated with the presence of exotic gecko species in South America, and discussed global distribution patterns. The updated distribution and list of exotic geckos in Argentina, highlights the need of monitoring these populations, encouraging the study of the biology of these invaders in the different environmental conditions where they are present.

Key words: Alien species; Dispersion; Lizards; Social media; South America.

## RESUMEN

Los geckos se encuentran entre los reptiles invasores más exitosos y han colonizado una amplia gama de hábitats y climas adecuados en todo el mundo. Fuera de su área de distribución nativa, suelen mostrar una clara asociación con hábitats urbanos y ambientes modificados por el ser humano. En Argentina, *Hemidactylus mabouia* y *Tarentola mauritanica* contaban con registros confirmados en algunas provincias. *Hemidactylus turcicus* fue registrado en Buenos Aires en 1989 a partir de un único registro, pero posteriormente su presencia se volvió dudosa al comprobarse que se trataba de un ejemplar mal identificado de *H. mabouia*. Iniciamos un proyecto de ciencia

ciudadana denominado Geckos Forasteros, con el objetivo de actualizar el estado de invasión de las especies de geckos en Argentina. Recopilamos registros de geckos a partir de redes sociales en línea y de un formulario digital del proyecto, en el cual las personas enviaban voluntariamente fotografías e información sobre sus hallazgos. Nuestros resultados confirman la presencia de *H. turcicus* en el país y revelan que la extensión de la invasión por *T. mauritanica* y *H. mabouia* es mucho mayor de lo que se pensaba previamente, incluyendo los registros más australes del mundo para las tres especies. Exploramos las variables ambientales asociadas con la presencia de especies exóticas de geckos en Sudamérica y discutimos los patrones de distribución global. La actualización de la distribución y el listado de geckos exóticos en Argentina, resalta la necesidad de monitorear estas poblaciones y fomenta el estudio de la biología de estos invasores en las diversas condiciones ambientales en las que se encuentran presentes.

Palabras claves: Especies exóticas; Dispersión; Lagartos; Redes sociales; Sudamérica.

## Introduction

Alien species are among the main threats to biodiversity and cause major economic losses (Bomford *et al.*, 2009). Gekkota is a highly functionally diverse clade of lizards, with species belonging to several functional groups (Pelegrin *et al.*, 2021). Geckos are among the most successful reptile invaders, yet their impact on native species remains debatable (Bomford *et al.*, 2009; Winck *et al.*, 2017). Gekkonidae is a lizard family with the highest success as invaders (Bomford *et al.*, 2009), and specifically, several species of the genus *Hemidactylus* are responsible for such success (Weterings and Vetter 2018). *Hemidactylus mabouia*, native to Central and East Africa, and *H. turcicus*, native to the Middle East and Mediterranean regions (Carranza and Arnold 2006; Locey and Stone 2006) have colonized a wide range of suitable habitats (and climates) around the world (Weterings and Vetter 2018). Similarly, *Tarentola mauritanica* (the Moorish Gecko, Phyllodactylidae) has dispersed from its native distribution in southern Europe and North Africa (Rato *et al.*, 2024), successfully establishing populations in countries from both the Old and the New World (Medina *et al.*, 2019). Populations of these exotic gecko species outside their native range show a clear association with urban habitats and human-modified habitats (Anjos and Rocha 2008; Weterings and Vetter 2018).

The first reports of *Hemidactylus mabouia* in Argentina date for the end of 1980's and was misidentified as *H. turcicus* by Williams (Williams

1989; Baldo *et al.*, 2008), while *Tarentola mauritanica* first arrival to Argentina was apparently in Buenos Aires in the 1970's (Williams and Kacoliris 2012). Even when the first records were from the 80's, the presence of *H. mabouia* could be traced back about 500 years ago, probably related to the slave trade by Europeans (Vanzolini 1978; Carranza and Arnold 2006).

*Hemidactylus mabouia* is widely distributed in Argentina and has been reported in cities in the provinces of Buenos Aires, Chaco, Corrientes, Formosa, Misiones, Entre Ríos, and Tucumán, and in the wild in the surroundings of the Parque Nacional Iguazú, Misiones (Genise and Montanelli 1991; Federico and Cacivio 2000; Baldo *et al.*, 2008; Álvarez *et al.*, 2009; Torres *et al.*, 2018). *Tarentola mauritanica* has been cited for the provinces of Buenos Aires, CABA, Salta, Tucumán, and Neuquén (Baldo *et al.*, 2008; Diaz Fernandez *et al.*, 2019; Medina *et al.*, 2019; Scrocchi *et al.*, 2019). Its presence in Rosario is known from informal records (Scrocchi *et al.*, 2019). Reports on the presence of *Hemidactylus turcicus* in Argentina are unclear. After being cited by Williams (1989), no new records for this species were reported, but suggested in some publications (Williams and Kacoliris 2012; Weterings and Vetter 2018).

Records for the three species in Argentina can be easily found on GBIF and websites where contributors voluntarily upload their own records with

photographic support. iNaturalist ([www.inaturalist.org](http://www.inaturalist.org)) and Ecoregistros ([www.ecoregistros.org](http://www.ecoregistros.org)) are the most common sites where people upload records of animals and plants in Argentina. In iNaturalist, contributors would suggest an identification for the photographed specimen, and then iNaturalist community members assess the observation and suggest an identification. When there is a consensus about the identity of a species, the observation is catalogued as “Research grade”, making it usable for research purposes through GBIF. In Ecoregistros, contributors assign species names when uploading their photos, and eventually, other community members can request a correction if the specimen is misidentified. Facebook groups about herpetology or general nature topics in Argentina also contain records for introduced geckos, generally from people asking about the identity of a given specimen.

A problem with these record sources is the lack of knowledge about diagnostic characteristics to correctly identify these exotic geckos. *Tarentola mauritanica*, *H. mabouia* and *H. turcicus* can be differentiated by looking at its toes and at the characteristics of its adhesive lamellae, specifically that from the fourth toe. *Tarentola mauritanica* has five full-size toes with an undivided series of toepads (or lamellae) extending along the entire underside surface of the digit. In addition, *Tarentola* has only claws in digits three and four. Unlike *Tarentola*, toe pads of both *Hemidactylus* species are divided and can be differentiated by the extension of the toe pads in the fourth toe. All digits of *Hemidactylus* have claws. *H. mabouia* has 7–9 lamellae, while *H. turcicus* has 9–10 under the fourth toe. Because of the different number of lamellae, toe pads in *H. turcicus* extend from the tip of the toe to its base, whereas in *H. mabouia*, they do not reach the base of the toe (Loveridge 1947; Abdala 1997; Krysko and Daniels 2005). There are also some minor differences in pholidosis and coloration between *Hemidactylus turcicus* and *H. mabouia*, based on the presence of larger and more numerous granular scales and a lighter coloration with light spots in *H. turcicus* (Loveridge 1947), but given the high variability in coloration patterns in both species (specially *H. mabouia*), using these characteristics could lead to misidentification.

Most specimens of *Hemidactylus* and *Tarentola* species published in iNaturalist, Ecoregistros, and Facebook were identified from a single picture, generally from a dorsal perspective, and generally

taken in poor conditions (using a cellphone camera, in poor lighting conditions, through a glass, out of focus, from a long distance, etc.), making identification difficult, especially among *Hemidactylus* species. Misidentified specimens can easily reach research grade in iNaturalist and end up in huge databases such as GBIF to be used by scientists in meta-analyses.

Despite the aforementioned problems, free digital platforms with mobile and desktop interfaces (such as iNaturalist) are recommended and very useful in citizen science projects (Encarnaç o et al., 2021). These have proven to be especially helpful in studies related to alien species, aiding in the detection and tracking of the spread of these species, in the prevention of their dispersal, and in the eradication of localized populations (Spear et al., 2017; Encarnaç o et al., 2021; Price-Jones et al., 2022). The valuable participation of citizen scientists can be formalized in research projects following some simple criteria, among which stand out: the use of multiple data collection methods, such as digital platforms, websites, personal surveys, forms, among others; mechanisms for data quality control and training provided by the researchers in charge; simplification of information related to the correct identification of taxa (Encarnaç o et al., 2021).

In November 2020 a group of scientists, science teachers, postdoctoral fellows, and graduate and undergraduate students started a citizen science project called “Geckos Forasteros en tu casa: est s seguro?” (Foreign geckos in your home: Are you sure/safe?). This countrywide project intended to update the distribution of the exotic geckos present in Argentina and to confirm the presence of *H. turcicus* in the country through direct interaction with Argentinian citizens.

## Materials and methods

On 9 November 2020 the project Geckos Forasteros en tu casa: est s seguro? (hereafter referred to as Geckos Forasteros) began to collect records from several parts of Argentina. We created project profiles on Facebook (<https://www.facebook.com/proyecto.geckos.forasteros>) and Instagram (<https://www.instagram.com/geckosforasteros/>), and created a research project in iNaturalist (<https://www.argentinat.org/projects/geckos-forasteros-en-tu-casa-estas-seguro>), as well as a webpage (<https://pelegrinlab.wixsite.com/lecoherp/gecks-forasteros>)

and an online form to collect records and pictures from observed geckos (<https://docs.google.com/forms/d/e/1FAIpQLScyEiLXwW11Du1BNBzDGmu6qCALcr77GFStMcb1LfWX7qTqBw/viewform>), which was shared to every possible observer. Along with these platforms, an email account was also created to answer inquiries by citizens.

To obtain high-quality records, the Geckos Forasteros team created a series of informative materials to assist potential observers in the process of obtaining pictures that allowed the identification of each of the species (*T. mauritanica*, *H. mabouia*, and *H. turcicus*). This was accomplished through a series of videos teaching how to capture, manipulate, take usable pictures, and how to identify exotic geckos in Argentina. In addition, an identification key was created (and a video teaching how to use it), and a series of digital and easily shareable materials showing key features to identify each species (Fig. 1), differences between native and exotic species, basic concepts of invasive species, and some extra information on toe pads of geckos.

In this form, participants were required to answer a series of questions, such as name, state, city, neighborhood, proximity to warehouses, markets, truck parking lots, and bus stations; characteristics used to identify the observed individual (according to options offered in a plate); and to attach pictures of the specimen, preferably with pictures of forelimb toe pads, to allow the differentiation between *H. mabouia* and *H. turcicus*. We also reviewed observations in iNaturalist and Ecoregistros, contacting contributors if misidentification occurred. In addition, iNaturalist contributors were asked to complete the project form to unify the information available for every observation. Records for each of the studied gecko species were systematically searched on iNaturalist. Each retrieved observation was subsequently revised and validated by checking both the species identification and the associated locality data. An observation was included and cited if the identification was confirmed as correct, the locality represented a novel record, and the observation had achieved "Research Grade" status; these records were cited using their GBIF record number (see GBIF, 2025) and listed in Appendix 1. Furthermore, if an identification was initially incorrect but the organism still belonged to one of the species of interest, and the locality was novel, the authors suggested a corrected identification, and cited the iNaturalist Observation Record number in Appendix 1. None

of the records reviewed in Ecoregistros (Ecoregistros, 2024) belonged to new localities for any of the species included.

Observations retrieved from the forms were filtered, and only those corresponding to the focus species were retained. Coordinates for each observation were extracted based on the available information (latitude and longitude for iNaturalist and Ecoregistros, coordinates to the closest locality reported in the forms) and plotted on a map.

We selected easily measurable traits so we could identify gecko species from the pictures sent by project participants or uploaded to iNaturalist or Ecoregistros. *Tarentola mauritanica* was differentiated from *Hemidactylus* species by the form of toe pads (enlarged and undivided in *Tarentola*, divided in *Hemidactylus*) and by the number of claws (only present in toes 3 and 4 in *Tarentola*, all toes with claws in *Hemidactylus*) (Abdala, 1997), and by the presence of large, strongly keeled tubercles in head and back, and the presence of small osteoderms (Levrat-Calviac and Zylberberg, 1986). Pictures obtained generally did not allow counting the number of lamellae in *Hemidactylus* species, so they were identified by the extension of toe pads (reaching the base of the fourth toe in *H. turcicus*, not reaching the base of the toe in *H. mabouia*). Also, as most pictures did not allow to see the lamellae, we used some external characteristics to identify *H. turcicus*, following the descriptions of Loveridge (1947): *Hemidactylus turcicus* has a characteristic dark stripe from the nostril, passing through the eye, to above the ear opening. The back is covered with small granular scales among which are scattered strongly keeled tubercles. These tubercles are dark but many are white or cream. *Hemidactylus mabouia* has no dark stripes in the head, and the back is covered by sparser, smaller and feebly tubercles. Color pattern in this species is highly variable. Also, the snout in *H. mabouia* is longer than in *H. turcicus*.

## Results

As of 17 May 2024, 2,680 people followed the project on Facebook and 4,152 on Instagram. After removing duplicated observations and misidentified species, we ended up with 1195 observations, 113 from Ecoregistros (29 *H. mabouia*, 1 *H. turcicus*, and 83 *T. mauritanica*), 225 from the project form (26 *H. mabouia*, 2 *H. turcicus*, 197 *T. mauritanica*) and 857 from iNaturalist (140 *H. mabouia*, 15 *H. turci-*

# Geckos Nativos vs. Exóticos de Argentina

## A

**Phyllopezus przewalskii** Nativo

**Tarentola mauritanica** Exótico

**Homonota borelli** Nativo

**Homonota horrida** Nativo

**Hemidactylus mabouia** Exótico

**Hemidactylus turcicus** Exótico

**Geckos forasteros en tu casa ¿estás seguro?**

**Dorsalmente son parecidos, la clave está en las patas!**

Dorsalmente, nuestros geckos nativos terrestres (*Homonota* sp.) tienen dos patrones de coloración: manchas irregulares o un patrón reticulado.

Patas SIN almohadillas desarrolladas

Las diferencias entre *Hemidactylus mabouia* y *H. turcicus* son sutiles en apariencia externa, pero más notorias en las almohadillas. En *H. turcicus* se extienden más allá de la inserción del dedo IV en la pata trasera. En *H. mabouia*, las almohadillas están principalmente en la parte distal del dedo IV de las patas traseras.

Infografía desarrollada por Nicolás Pellegrin, Laboratorio de Ecología y Conservación de la Herpetofauna, IDEA (CONICET-UNC) para el proyecto de Ciencia Ciudadana "Geckos Forasteros en tu casa: ¿estás seguro?". Diciembre de 2020.

**Geckos Nativos vs. Exóticos de Argentina**

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Foto: B.R. Fernández

Foto: J.P.G de La Vega

Foto: Fero Bednar

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## B

Instituto de Diversidad y Ecología Animal - IDEA (CONICET/UNC)  
Centro de Zoología Aplicada - CZA (FEEyN, UNC)

### Geckos forasteros en tu casa ¿estás seguro? \* \* \*

Proyecto de Ciencia Ciudadana - Guía de Identificación de Geckos Exóticos - @geckosforasteros

Instagram | Facebook

**Tarentola mauritanica**

- Dedos con almohadillas enteras.
- Garras visibles sólo en dos dedos.
- Apariencia espinosa (escamas quilladas).

**Hemidactylus turcicus**

- Dedos con almohadillas divididas y garras visibles en todos los dedos.
- Escamas más redondeadas.
- En las patas traseras las almohadillas se extienden hasta la base del dedo IV.
- Escamas granulares grandes, bien visibles en el dorso.

**Hemidactylus mabouia**

- En las patas traseras las almohadillas NO se extienden hasta la base del dedo IV.
- Escamas granulares pequeñas y poco evidentes.

**Geckos forasteros en tu casa ¿estás seguro?**

Fotos: *T. mauritanica* y *H. turcicus*: B. R. Fernández; *H. mabouia*: N. Pellegrin

Dibujos: M. Sosa

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**Figure 1.** Example of material used in the citizen-science project showing how to identify exotic gecko species. A) Plate comparing common native gecko species with the three exotic geckos; B) Identification key used to identify exotic gecko species.

*cus*, and 702 *T. mauritanica*, Fig. 2). Two hundred and thirty eight people from 18 of the 24 states (23 provinces plus Ciudad Autónoma de Buenos Aires - CABA, Federal District) of Argentina completed and sent the online form of the project. None of the records reviewed in Ecoregistros (Ecoregistros, 2024) belonged to new localities for any of the species included.

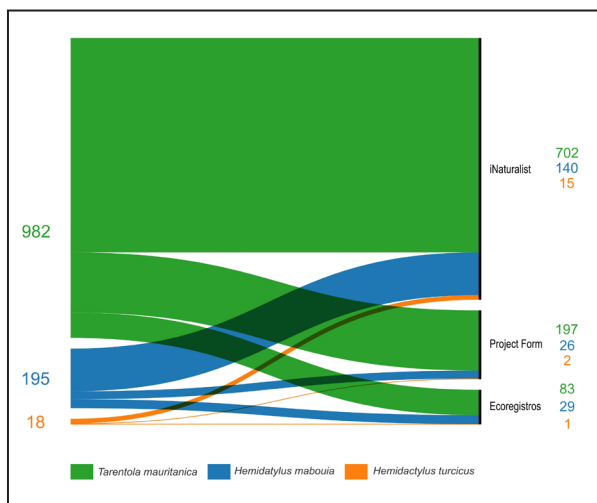
Ninety new localities from 15 states were reported for the three species (Appendix 1, Fig. 3). *Hemidactylus mabouia* was reported for Bue-

nos Aires, CABA, Santa Fe, Tucumán, Salta, Jujuy, Chaco, Formosa, Entre Ríos, Corrientes, Misiones, and Córdoba. New localities for the species were registered in the provinces of Chaco, Córdoba, Corrientes, Formosa, Jujuy, Misiones and Santa Fe (Appendix 1, Fig. 4 and Fig. 5). *Tarentola mauritanica* was reported for Buenos Aires, CABA, Santa Fe, Entre Ríos, Jujuy, Tucumán, Córdoba, La Pampa, San Luis, Río Negro, Mendoza, Neuquén, and Tierra del Fuego, with new localities registered for Buenos Aires, Córdoba, Entre Ríos, Jujuy, La Pampa, Mendoza, Río Negro, Santa Fe, San Luis and Tierra del Fuego (Appendix 1, Fig. 4 and Fig. 5). *Hemidactylus turcicus* was reported for Buenos Aires, CABA, and Santa Fe, representing the first confirmed records of the species for Argentina (Appendix 1, Fig. 4 and Fig. 5). The oldest verifiable record for the species in Argentina corresponds to a specimen from Rosario dating January, 2002 (specimen MACN37736).

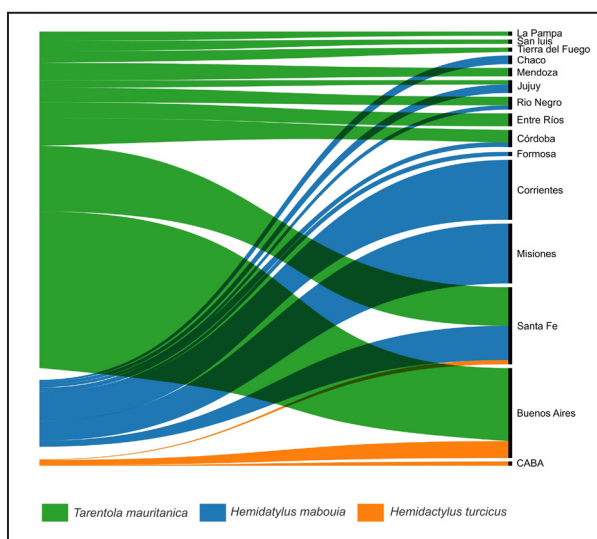
## Discussion

This work updates the list and distribution of exotic gecko species in Argentina, confirming the presence of *Hemidactylus turcicus* in the country and revealing that the extent of the invasion by *Tarentola mauritanica* and *H. mabouia* in the country is far larger than previously thought, reporting 90 new localities with presence of at least one exotic gecko species. *T. mauritanica* is present in 13 of the 24 Argentinean districts (23 provinces plus CABA, the Federal District), when previous records only referred to four, being expressively present in numerous localities. *H. mabouia* also had its known distribution extended, from seven to 12 districts and numerous new localities. This study highlights the value of citizen science in projects involving alien species, enabling wider sampling areas and helping to have a more informed and engaged local community on environmental issues.

Until this work, the only published record for *H. turcicus* in South America was that of Williams (1989) which was later revised as being a juvenile *H. mabouia* (Baldo *et al.*, 2008) and leaving *H. turcicus* with no records in Argentina and, thus, a dubious presence in South America. Wetering and Vetter (2018) analyzed the worldwide potential distribution of *Hemidactylus* species, using records retrieved from GBIF. These records included four Brazilian specimens from 1988 and 1989 (deposited in the Museum of Comparative Zoology, Harvard



**Figure 2.** Diagram depicting the importance of each source of information used in this project for each of the studied species. Numbers represent quantity of records. Colors indicate the species identity: green, *T. mauritanica*; blue, *H. mabouia*; orange, *H. turcicus*.



**Figure 3.** Diagram representing the number of new records for each of the species and for each Argentinean states. The wider the lines, the higher the number of localities where the species was recorded for the specific state. Colors indicate the species identity: green, *T. mauritanica*; blue, *H. mabouia*; orange, *H. turcicus*.

University), iNaturalist records from Argentina, and some specimens deposited in the Argentinian Museum of Natural History (MACN), collected in Rosario (province of Santa Fe), and CABA. We were not able to confirm the identity of *Hemidactylus* specimens collected in Brazil. These records could correspond to misidentified specimens (corresponding to *H. mabouia*) or to isolated individuals and not to established populations of *H. turcicus*, since no other individuals of this species were recorded since then in the whole country. The individuals from Argentina deposited in the MACN were confirmed as *H. turcicus* by the authors, and were collected in 2002 and 2011 in the city of Rosario (MACN 37736, 37820, 37821, 41952, 41953) and 2002 in CABA (MACN 38213). Here we confirm the presence of *H. turcicus* in Argentina, and extending its presence to the cities of Ituzaingó, Lanús, Quilmes, and San Pedro in the Province of Buenos Aires and Santa Fe in the province of Santa Fe, representing the only known records for the species in South America and the southernmost records for the species in the world. The northernmost known established populations of *H. turcicus* corresponds to those found in Nottingham and Hull, UK, at about 53° latitude North (Da Silva *et al.*, 2024), showing the extreme adaptability of the species.

The distribution of invasive gecko species in Argentina shows a segregated pattern between *H. mabouia* and *T. mauritanica*, where *H. mabouia* is concentrated mainly in north-east Argentina, with few records in centre and north of the country. According to Vanzolini (1978), the southern limit of the distribution of *H. mabouia* in South America was Porto Alegre (30° latitude South) with a dubious record for Montevideo, Uruguay (~35° latitude South). The first confirmed record for Buenos Aires (~34.5° latitude South; Williams, 1989) dates about ten years after Vanzolini's work. Thirty-five years later, there are no records of established populations for the species south of latitude 35° S. The distribution of *H. mabouia* in continental South America seems to fit the isotherm of 18-20 °C, avoiding mean temperatures below 18 °C (Vanzolini, 1978). The present distribution of the species in Argentina approximates Vanzolini's prediction; the southernmost records for established populations of this species are located between the isotherms of 16-18 °C (CABA) and 18-20 °C (Villa Dolores, Córdoba). The southernmost record for *H. mabouia* in Argentina—at 38.9° latitude South—is also the southernmost

record ever reported for the species and refers to an individual found in transit in a cargo truck. Notably, the southernmost published record for *H. mabouia* in its native continent is in South Africa at about 33° South (Agarwal *et al.*, 2021); the southernmost African record in iNaturalist is in Bredascorp, at 34.5° latitude South (iNaturalist, 2024a). It is worth mentioning that northernmost records (Ontario, CA and London, UK) for the species are most likely occasional findings associated with plant trade and other commercial activities (iNaturalist, 2024b).

Records for *T. mauritanica* are concentrated in a belt across the central portion of Argentina, mainly in the eastern part, but with extreme records both in northern (Jujuy, this work) and southern (Tierra del Fuego, this work) Argentina. The individual of *T. mauritanica* found in Rio Grande (Tierra del Fuego) is, until now, the southernmost record for the species ever reported. It refers to an individual found in a car traveling from Buenos Aires, and it does not represent an established population. However, it highlights its high capacity of dispersion using human transportation. The species' distribution probability is linked to regions with low to moderate precipitation, moderate to high temperatures, low temperature seasonality, and low to moderate mean diurnal range (Rato *et al.*, 2024), and according to future projections, habitat suitability in Argentina was predicted to decrease (Rato *et al.*, 2024). However, the progression of records for *T. mauritanica* in the country between late 1970's and the present seem to indicate a rapid dispersion, especially in central Argentina. *T. mauritanica* is a species with high functional diversity and generalist biology (Pelegri *et al.*, 2021), which may allow the adaptation to the variety of climates existing in Argentina. Probably, training the SD models with the records available in this work would end in different predictions for the occupation of the species in the future.

Records for *H. turcicus* in Argentina are scarce and distributed in a very reduced area. The oldest evidence of presence dates from 2002, so it is likely a result of a recent arrival and colonization by the species. *H. turcicus* shows a higher tolerance to cold climates than *H. mabouia*, so, if its populations succeed and disperse, it may segregate spatially from *H. mabouia* (Weterings and Vetter, 2018). The segregated distribution of *H. mabouia* and *T. mauritanica* may indicate different thermal affinities, as both are associated with anthropic environments. However, *T. mauritanica* is not present in Brasil (but it is



**Figure 4.** Voucher specimens retrieved from Geckos Forasteros online form, according to the localities listed in Appendix 1. *Hemidactylus mabouia*: Province of Corrientes: A) Mercedes, B) San Cosme, C) Santa Ana, D) Santo Tomé. Province of Jujuy: E) San Salvador de Jujuy. Misiones: F) Puerto Esperanza. Province of Río Negro: G) Cipolletti. *Hemidactylus turcicus*: Province of Buenos Aires: H) Ituzaingó. *Tarentola mauritanica*: Province of Buenos Aires: I) Pilar, J) San Clemente del Tuyú, K) Santa Lucía, L) Tandil. Province of Córdoba: M) Córdoba, N) Villa Las Rosas, O) Villa María. Province of Entre Ríos: P) Colón, Q) Concepción del Uruguay. Province of Jujuy: R) San Salvador de Jujuy; Province of La Pampa: S) Santa Rosa. Province of Río Negro: T) Cipolletti. Province of San Luis: U) Naschel. Province of Tierra del Fuego: V) Río Grande.

present in Uruguay, east from Buenos Aires, in the same latitudinal belt (Achaval and Gudynas, 1983), and *H. mabouia* is not present in Argentina south to latitude 39°.

The study of invasive gecko species received little attention in Argentina, probably because of the strong association of these species with urban environments (Weterings and Vetter, 2018) and scarcity of clear evidence about negative impacts of these invasive geckos on the native fauna (Williams *et al.*, 2016; Winck *et al.*, 2017; Borroto-Páez and Pérez, 2019). The CABA is invaded by *T. mauritanica*, *H. mabouia* and *H. turcicus*. However, since no native gecko species are present in the city (nor

in the province of Buenos Aires; Abdala *et al.*, 2012), and the lizard fauna in CABA urban environments is probably reduced to the Gymnophthalmid *Cercosaura schreibersii* (Abdala *et al.*, 2012; Williams and Kacolis, 2012), potential negative effects on native lizard fauna were never a concern. By updating the distribution and list of exotic geckos, here we set a warning about the possible interactions between these exotic species and native lizards and amphibians, encouraging the study of the biology of these invaders in the different environmental conditions where they are present. The results of this project, along with future new records (hopefully with an improved accuracy in the identification) could im-



**Figure 5.** Maps showing the distribution of exotic gecko species in Argentina using A) literature records, and B) records obtained in the project Geckos Forasteros. Blue circles: *H. mabouia*; green circles: *H. turcicus*; red circles: *T. mauritanica*.

prove forecasts of species presence and population tendency. By applying species distribution models to assess the distribution of exotic gecko species for present and future conditions, researchers could be able to address hypotheses regarding interactions with native species in future scenarios of climate change.

The project Geckos Forasteros played an important role, offering information not just about the biology of the gecko species studied, but also about native species, bringing awareness about the problem with alien and invasive species in Argentina. The use of citizen science is a useful tool to sample large areas in a fast way and conduct studies in urban areas (Spear *et al.*, 2017). Citizen science stands out as a valuable tool for studying new records, monitoring, distribution, and control measures of invasive species (Encarnação *et al.*, 2021). The use of this tool in research projects focused on amphibians and reptiles is rare (Price-Jones *et al.*, 2022); however, there are examples of successful application, such as the citizen-science project Reptiles and Amphibians of Southern California (RASCals; see Spear *et al.*, 2017). This work notably highlights this tool for urban ecology studies, achieving a much higher number of records compared to those from museum records (Spear *et al.*, 2017). Finally, research projects that include or are based on citizen science become highly important as they actively involve local citizens, making them more aware of local ecological aspects and transforming them into part of the solution to environmental issues. We hope that this work serves to encourage the incorporation of citizen science in other research projects and that it remains as a monitoring tool for the distribution of exotic gecko species in Argentina.

### Acknowledgments

We like to thank all the people who actively contributed with this project and to the anonymous reviewers for their suggestions to improve our manuscript. We also thank Julián Faivovich and Santiago Javier Nenda from Museo Argentino de Ciencias Naturales (MACN), for sharing information about specimens deposited in the MACN Herpetological Collection. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001

### Literature cited

Abdala, C.; Acosta, J.; Acosta, J.C.; Álvarez, B.B.; Arias, F.; Avila, L.J.; Blanco, G.; Bonino, M.; Boretto, J.; Brancatelli,

- G.; Breitman, F.; Cabrera, M.R.; Cairo, S.; Corbalán, V.; Hernando, A.; Ibagüengoytia, N.; Kacolis, F.; Laspiur, A.; Montero, R.; Morando, M.; Pelegrin, N.; Pérez, C.F.; Quinteros, S.A.; Semhan, R.; Tedesco, M.; Vega, L. & Zalba, S. 2012. Categorización del estado de conservación de las lagartijas y anfisbenas de la República Argentina. *Cuadernos de Herpetología* 26: 215-248.
- Abdala, V. 1997. Los geckos de Argentina. Serie Monográfica y Didáctica. 29: 1-44.
- Achaval, F. & Gudynas, E. 1983. Hallazgo de *Tarentola mauritanica* (L., 1758) (Lacertilia, Gekkonidae) en el Uruguay. *Boletín de la Sociedad de Zoología de Uruguay* (2a época) 1: 7-10.
- Agarwal, I.; Ceriaco, L.M.P.; Metallinou, M.; Jackman, T.R. & Bauer, A.M. 2021. How the African house gecko (*Hemidactylus mabouia*) conquered the world. *Royal Society Open Science* 8: 210749.
- Álvarez, B.B.; Ruiz García, J.A.; Céspedes, J.A.; Hernando, A.B.; Zaracho, V.H.; Calamante, C.C. & Aguirre, R.H. 2009. Herpetofauna, provinces of Chaco and Formosa, Chaco Oriental region, north-eastern Argentina. *Check List* 5: 74-82.
- dos Anjos, L.A. & da Rocha, C.F. 2008. A Lagartixa *Hemidactylus mabouia* Moreau de Jonnes, 1818 (Gekkonidae): uma espécie exótica e invasora amplamente estabelecida no Brasil. *Natureza e Conservação* 6: 78-89.
- Baldo, D.; Borteiro, C.; Brusquetti, F.; García, J.E. & Pringioni, C. 2008. Reptilia, Gekkonidae, *Hemidactylus mabouia*, *Tarentola mauritanica*: Distribution extension and anthropogenic dispersal. *Check List* 4: 434-438.
- Bomford, M.; Kraus, F.; Barry, S.C. & Lawrence, E. 2009. Predicting establishment success for alien reptiles and amphibians: a role for climate matching. *Biological Invasions* 11: 713-724.
- Borrotto-Páez, R. & Pérez, D.R. 2019. Competitive interference between an endemic Cuban Green Anole (*Anolis porcatius*) and invasive Tropical House Geckos (*Hemidactylus mabouia*). *Reptiles & Amphibians* 26: 43-46.
- Carranza, S. & Arnold, E.N. 2006. Systematics, biogeography, and evolution of *Hemidactylus* geckos (Reptilia: Gekkonidae) elucidated using mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* 38: 531-545.
- Da Silva, S.M.; Maka, A.; Hartman, T.; Wollenberg, K.V. & Gilbert, E. 2024. Two established introduced populations of the synanthropic gecko *Hemidactylus turcicus* (Linnaeus, 1758) in England. *Herpetology Notes* 17: 407-410.
- Díaz Fernández, L.E.; Paz, V.A. & Valdecantos, M.S. 2019. First checked arrival of *Tarentola mauritanica* (Linnaeus, 1758) in Salta, Argentina (Squamata; Phyllodactylidae). *Herpetology Notes* 12: 853-854.
- EcoRegistros. 2024. Community records database. Exported from <https://www.ecoregistros.org> on 2024-05-12.
- Encarnação, J.; Teodósio, M. & Morais, P. 2021. Citizen Science and Biological Invasions: A Review. *Frontiers in Environmental Science* 8: 602980.
- Federico, L. & Cacivio, P.M. 2000. Geographic distribution: *Hemidactylus mabouia*. *Herpetological Review* 31: 53.
- iNaturalist. 2024a. iNaturalist Research-grade Observations. iNaturalist.org. Occurrence dataset <https://doi.org/10.15468/ab3s5x> accessed via GBIF.org on 2024-07-30.
- iNaturalist. 2024b. Observations of *Hemidactylus mabouia*. Exported from <https://www.inaturalist.org> on 2024-07-30.

- GBIF. 2025. Global Biodiversity Information Facility. Occurrence Download <https://doi.org/10.15468/dl.ybfnpg>
- Genise, J.F. & Montanelli, S.B. 1991. Primer hallazgo de *Hemidactylus mabouia* (Moreau de Jones) en la Argentina. *Boletín de la Asociación Herpetológica Argentina* 7: 23.
- Krysko, K.L. & Daniels, K.J. 2005. A key to the geckos (Sauria: Gekkonidae) of Florida. *Caribbean Journal of Science* 41: 28-36.
- Levrat-Calviac, V. & Zylberberg, L. 1986. The structure of the osteoderms in the gekko *Tarentola mauritanica*. *American Journal of Anatomy* 176:437-446.
- Locey, K.J. & Stone, P.A. 2006. Factors affecting range expansion in the introduced Mediterranean Gecko, *Hemidactylus turcicus*. *Journal of Herpetology* 40: 526-530.
- Loveridge, A. 1947. Revision of the African lizards of the family Gekkonidae. *Bulletin of the Museum of Comparative Zoology* 98: 1-469.
- Medina, J.A.O.; Cen, D.I.C.; Noh, M.M.C. & Vázquez, J.R.C. 2019. First record of the Moorish Gecko, *Tarentola mauritanica* (Linnaeus, 1758) (Squamata: Phyllodactylidae), in Mexico. *Herpetology Notes* 12: 971-974.
- Pelegrin, N.; Winemiller, K.O.; Vitt, L.J.; Fitzgerald, D.B. & Pianka, E.R. 2021. How do lizard niches conserve, diverge or converge? Further exploration of saurian evolutionary ecology. *BMC Ecology and Evolution* 21: 149.
- Price-Jones, V.; Brown, P.; Adriaens, T.; Tricarico, E.; Farrow, R.A.; Cardoso, A.C.; Gervasini, E.; Groom, Q.; Reyserhove, L.; Schade, S. & Tsinaraki, C. 2022. Eyes on the aliens: citizen science contributes to research, policy and management of biological invasions in Europe. *NeoBiota* 78: 1-24.
- Rato, C.; Silva-Rocha, I. & Sillero, N. 2024. What does the future hold for a thermophilic and widely introduced gekko, *Tarentola mauritanica* (Squamata: Phyllodactylidae)? *Biological Invasions* 26: 1061-1074.
- Scrocchi, G.; Stazzonelli, J.C. & Cabrera, P. 2019. Nuevas citas de *Squamata* (Gekkonidae, Phyllodactylidae y Dipsadidae) para la provincia de Tucumán, Argentina. *Cuadernos de Herpetología* 33: 75-78.
- Spear, D.; Pauly, G. & Kaiser, K. 2017. Citizen science as a tool for augmenting museum collection data from urban areas. *Frontiers in Ecology and Evolution* 5: 86.
- Torres, P.J.; Escalante, O.M. & Cardozo, D.E. 2018. First record of the invasive *Hemidactylus mabouia* (Moreau de Jonnés, 1818) (Squamata, Gekkonidae), in the dry Chaco, Argentina. *Check List* 14: 633-636.
- Vanzolini, P.E. 1978. On South American *Hemidactylus* (Sauria, Gekkonidae). *Papéis Avulsos de Zoologia* 31: 307-343.
- Weterings, R. & Vetter, K.C. 2018. Invasive house geckos (*Hemidactylus* spp.): their current, potential and future distribution. *Current Zoology* 64: 559-573.
- Williams, J. 1989. Primer hallazgo del Gecko Mediterráneo *Hemidactylus turcicus* (L., 1758) (Lacertilia: Gekkonidae) en la Argentina. *Boletín de la Asociación Herpetológica Argentina* 5: 14.
- Williams, J.D. & Kaccoliris, F.P. 2012. Los paisajes perdidos de Buenos Aires. Fundación de Historia Natural "Félix Azara". Buenos Aires.
- Williams, R.; Pernetta, A.P. & Horrocks, J.A. 2016. Outcompeted by an invader? Interference and exploitative competition between tropical house gecko (*Hemidactylus mabouia*) and Barbados leaf-toed gecko (*Phyllodactylus pulcher*) for diurnal refuges in anthropogenic coastal habitats. *Integrative Zoology* 11: 229-238.
- Winck, G.R.; Almeida-Santos, M.; Dorigo, T.A.; Telles, F.B. & da Rocha, C.F. 2017. When invasion may not be harmful: niche relations in a lizard assemblage. *Biotropica* 49: 117-129.

## Appendix I

List of new localities where specimens of *Tarentola mauritanica*, *Hemidactylus mabouia* and *H. turcicus* were recorded. Latitude and longitude are expressed in decimal degrees. Voucher specimens are indicated for each locality. GBIF: Gbif record number, iNaturalist: iNaturalist observation number. LECO: herpetological collection of the Laboratory of Ecology and Conservation of Herpetofauna, Instituto de Diversidad y Ecología Animal, CONICET. MACN: Museo Argentino de Ciencias Naturales (Argentina). The authors of pictures used as voucher (see Fig. 1) are also included.

Province	Locality	Latitude	Longitude	Voucher
<i>Hemidactylus mabouia</i>				
Chaco	Colonia Benitez	-27.329°	-58.953°	GBIF: 4440790714
Chaco	Juan José Castelli	-25.938°	-60.601°	GBIF: 4846801728
Córdoba	Villa Dolores	-31.949°	-65.188°	LECOH00741
Corrientes	Bella Vista	-28.506°	-59.038°	GBIF: 4440852589
Corrientes	Gobernador Virasoro	-28.054°	-56.014°	iNaturalist: 202888997
Corrientes	Itaí	-27.273°	-58.243°	iNaturalist: 152401125
Corrientes	Ituzaingó	-27.584°	-56.686°	GBIF: 4440614229
Corrientes	Loreto	-27.774°	-57.275°	iNaturalist: 75665970
Corrientes	Mercedes	-29.184°	-58.075°	Fig. 1A – Yamila Parola
Corrientes	Paso de la Patria	-27.314°	-58.562°	GBIF: 4440595389
Corrientes	Paso de los Libres	-29.707°	-57.116°	GBIF: 4519122509
Corrientes	San Cosme	-27.371°	-58.511°	Fig. 1B – Valeria Arraigada
Corrientes	San Luis del Palmar	-27.512°	-58.560°	iNaturalist: 143794320

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Corrientes	San Roque	-28.571°	-58.706°	iNaturalist: 77113150
Corrientes	Santa ana	-27.458°	-58.656°	Fig. 1C – Oscar Galli Merino
Corrientes	Santo Tomé	-28.552°	-56.0452°	Fig. 1D – Micaela Romero
Corrientes	Yapeyú	-29.464°	-56.816°	GBIF: 4596892880
Formosa	Pirané	-27.737°	-59.112°	iNaturalist: 37857018
Jujuy	Libertador San Martín	-23.817°	-64.799°	GBIF: 4867732604
Jujuy	San Salvador de Jujuy	-24.186°	-65.319°	Fig. 1E – Lucas Jure
Misiones	Candelaria	-27.447°	-55.585°	GBIF: 4522460132
Misiones	Comandante Andresito	-25.673°	-54.042°	GBIF: 4014866384
Misiones	Concepción de la Sierra	-27.981°	-55.515°	GBIF: 4518973256
Misiones	El Dorado	-26.407°	-54.637°	iNaturalist: 108820055
Misiones	General Manuel Belgrano	-25.534°	-54.134°	GBIF: 4133894347
Misiones	Gobernador Roca	-27.198°	-55.469°	GBIF: 4528381344
Misiones	Guaraní	-27.226°	-54.017°	GBIF: 4440898204
Misiones	Iguazú	-25.828°	-54.537°	iNaturalist: 125906494
Misiones	Leandro N. Alem	-27.615°	-55.328°	GBIF: 3912259496
Misiones	Montecarlo	-26.559°	-54.776°	iNaturalist: 77128085
Misiones	Oberá	-27.462°	-55.122°	iNaturalist: 122697934
Misiones	Puerto Esperanza	-26.026°	-54.614°	Fig. 1F – Macarena Fernandez
Misiones	San Antonio	-26.057°	-53.735°	GBIF: 3032103916
Misiones	San Pedro	-26.621°	-54.110°	iNaturalist: 180019273
Rio Negro	Cipolletti	-38.933	-67.989°	Fig. 1G – Ignacio Hernández
Santa Fe	Avellaneda	-29.117°	-59.659°	iNaturalist: 74263007
Santa Fe	Florencia	-28.045°	-59.226°	GBIF: 4512191423
Santa Fe	General Obligado	-28.506°	-59.263°	GBIF: 4606745214
Santa Fe	Las Toscas	-28.350°	-59.261°	iNaturalist: 193197211
Santa Fe	Reconquista	-29.169°	-59.651°	iNaturalist: 195128612
Santa Fe	Santa Fe	-31.601°	-60.698°	GBIF: 3881755856
Santa Fe	Vera	-29.457°	-60.203°	GBIF: 4519123196
Santa Fe	Villa Ocampo	-28.484°	-59.354°	GBIF: 4096416791
<b><i>Hemidactylus turcicus</i></b>				
Buenos Aires	Ituzaingó	-34.648°	-58.706°	Fig. 1H – Pablo Miranda
Buenos Aires	Lanús	-34.708°	-58.394°	iNaturalist: 217385599
Buenos Aires	Quilmes	-34.721°	-58.255°	GBIF: 4528230293
Buenos Aires	San Pedro	-33.674°	-59.666°	iNaturalist: 101228791
Ciudad Autónoma de Buenos Aires (CABA)	-34.608°	-58.430°	MACN 38213	
Santa Fe	Rosario	-32.950°	-60.682°	MACN 37736, 37820, 37821, 41952, 41953
<b><i>Tarentola mauritanica</i></b>				
Buenos Aires	Bahía Blanca	-38.704°	-62.272°	iNaturalist: 202226121
Buenos Aires	Cañuelas	-35.039°	-58.746°	iNaturalist: 192066164
Buenos Aires	Cariló	-37.159°	-56.889°	iNaturalist: 141729805
Buenos Aires	Junín	-34.588°	-60.949°	GBIF: 3858196841
Buenos Aires	La Plata	-34.934°	-57.956°	GBIF: 4606646261

Buenos Aires	Los Toldos	-35.001°	-61.035°	GBIF: 4522726666
Buenos Aires	Luján	-34.563°	-59.121°	iNaturalist: 195419295
Buenos Aires	Mar de Ajó	-36.695°	-56.679°	GBIF: 4430998770
Buenos Aires	Mar del Plata	-38.018°	-57.561°	iNaturalist: 116420398
Buenos Aires	Necochea	-38.542°	-58.735°	iNaturalist: 152400088
Buenos Aires	Pehuajó	-35.811°	-61.898°	iNaturalist: 204791302
Buenos Aires	Pilar	-34.444°	-58.807°	Fig. 1I – Daniel Aguirre
Buenos Aires	Saladillo	-35.652°	-59.788°	GBIF: 4034750030
Buenos Aires	San Clemente del Tuyú	-36.365°	-56.718°	Fig. 1J – Andrea Cabrera
Buenos Aires	Santa Lucía	-33.878°	-59.876°	Fig. 1K – Tomás Bione
Buenos Aires	Tandil	-37.314°	-59.135°	Fig. 1L – Sofía Zurzolo
Buenos Aires	Zárate	-34.094°	-59.022°	GBIF: 4528344537
Córdoba	Córdoba	-31.434°	-64.149°	Fig. 1M – Mariano Romero
Córdoba	Villa Las Rosas	-31.949°	-65.054°	Fig. 1N – Liz Rodríguez
Córdoba	Villa María	-32.414°	-63.243°	Fig. 1O – Jimena Pereyra
Entre Ríos	Colón	-32.224°	-58.144°	Fig. 1P – Claudio Trebaux
Entre Ríos	Concepción del Uruguay	-32.482°	-58.239°	Fig. 1Q – Facundo Cabrera
Entre Ríos	Paraná	-31.710°	-60.563°	GBIF: 4006705068
Jujuy	San Salvador de Jujuy	-24.205°	-65.271°	Fig. 1R – Mariano Benitez
La Pampa	Santa Rosa	-36.607°	-64.274°	Fig. 1S – Lautaro Fernández Artico
Mendoza	Guaymallén	-32.894°	-68.826°	GBIF: 2851323552
Mendoza	Malargue	-35.487°	-69.584°	GBIF: 4111594404
Rio Negro	Cipolletti	-38.933	-67.989°	Fig. 1T – Ignacio Hernández
Rio Negro	Villa Regina	-39.101°	-67.079°	iNaturalist: 193710657
Santa Fe	Carcaraña	-32.855°	-61.155°	GBIF: 2641625312
Santa Fe	Casilda	-33.036°	-61.159°	iNaturalist: 40858266
Santa Fe	Fray Luis Beltrán	-32.791°	-60.729°	GBIF: 3947576114
Santa Fe	Granadero Baigorria	-32.839°	-60.701°	GBIF: 3070626672
Santa Fe	Rafaela	-31.254°	-61.487°	iNaturalist: 45157622
Santa Fe	Rosario	-32.949°	-60.665°	GBIF: 2603417694
Santa Fe	Santa Teresa	-33.441°	-60.789°	iNaturalist: 186855758
Santa Fe	Santa Teresa	-33.441°	-60.789°	iNaturalist: 186855758
Santa Fe	Santo Tomé	-31.671°	-60.767°	GBIF: 4177065048
Santa Fe	Venado Tuerto	-33.749°	-61.975°	GBIF: 4067321101
San luis	Naschel	-32.916°	-65.373°	Fig. 1U – Luis Ginés
Tierra del Fuego	Río Grande	-53.787°	-67.709°	Fig. 1V – Manuela Gómez