

Original article

New records of the introduced gecko *Lepidodactylus lugubris* (Duméril & Bibron, 1836) (Squamata: Gekkonidae) in Colombia and update of its geographic range in the country

Nuevos registros del geco introducido *Lepidodactylus lugubris* (Duméril & Bibron, 1836) (Squamata: Gekkonidae) en Colombia y actualización de su distribución geográfica en el país

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Abstract

The mourning gecko (*Lepidodactylus lugubris*) is one of the most widely distributed lizard species in the world due to the frequent expansion of its range through accidental translocation by humans. The increased ability of *L. lugubris* to disperse by anthropic means is facilitated by its unisexual reproduction (parthenogenesis) and saltwater-resistant eggs. The species has been currently reported from several localities in western and central Colombia, extending over 12 of the 32 departments of the country. In this study, we summarize and update the distribution of *L. lugubris* in Colombia based on both published records and new localities supported by photographic evidence that we obtained or was previously deposited in the iNaturalist database. We also obtained additional records after the revision of several herpetological collections. Our new localities fill distribution gaps and extend the range of the species to the western slopes of the Cordillera Oriental and the northwestern limit of the country's Amazon region. The new records also represent the first for *L. lugubris* in five departments of Colombia. We discuss the possible dispersal routes and present anecdotal observations on its interaction with other introduced gecko species. Our work highlights the importance of platforms such as iNaturalist to pinpoint the distribution of introduced species, especially for lesser-known taxa and geographical regions.

Keywords: Geographic distribution; iNaturalist; Introduced species; Mourning gecko; Range extension.

Resumen

El geco enlutado (*Lepidodactylus lugubris*) es una de las especies de lagartijas más ampliamente distribuidas en el mundo por la frecuente expansión de su área de distribución debida a su translocación accidental por parte del ser humano. La mayor capacidad de dispersión de *L. lugubris* por medios antrópicos se ve facilitada por su reproducción unisexual (partenogénesis) y sus huevos resistentes al agua salada. La especie ha sido registrada en varias localidades del occidente y centro de Colombia, extendiéndose a 12 de los 32 departamentos del país. En este estudio resumimos y actualizamos la distribución de *L. lugubris* en Colombia basándonos tanto en registros publicados como en las nuevas localidades determinadas a partir de evidencias fotográficas que obtuvimos o que fueron depositadas previamente en la base de datos de iNaturalist. Además, obtuvimos registros adicionales tras la revisión de varias colecciones herpetológicas. Nuestras nuevas localidades llenan

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vacíos en la distribución de la especie y la amplían a las laderas occidentales de la cordillera Oriental y el límite noroeste de la región amazónica del país. Asimismo, los nuevos registros representan los primeros de *L. lugubris* en cinco departamentos de Colombia. Discutimos sus posibles rutas de dispersión y presentamos observaciones anecdóticas sobre su interacción con otras especies de geocos introducidos. Nuestro trabajo también pone de manifiesto la importancia de plataformas como iNaturalist para precisar la distribución de las especies introducidas, especialmente para taxones y regiones geográficas menos conocidas.

Palabras claves: Distribución geográfica; iNaturalist; Especies introducidas; Geco de luto; Ampliación de área de distribución.

Introduction

The introduction of different species in non-native places around the world has occurred mainly due to human intervention in search of populating new territories and maintaining trade routes. This has resulted in the existence of a diversity of synanthropic species that can generate negative impacts on invaded ecosystems (Correoso, 2005). Squamate reptiles have been one of the most frequently introduced groups to different regions of the world due to their morphological characteristics that allow resistance to extreme handling and transport conditions (Castaño-Mora, 2002; Arroyave, 2015). Such is the case for the family Gekkonidae, which is an almost cosmopolitan group, as some species are now distributed around the globe due to both natural and human-mediated interoceanic dispersal (Vences *et al.*, 2004; Detwiler & Criscione, 2014; Hoogmoed & Avila-Pires, 2015). The accidental introduction of species of geckos to different parts of the world has been facilitated by some morphological characteristics, such as small body sizes, high fecundity, rapid maturation, calcareous eggs resistant to saltwater, and high population densities (Brown & Duffy, 1992; Case *et al.*, 1994; Kolbe *et al.*, 2016; Somaweera *et al.*, 2020). These characteristics allow geckos to disperse and adapt easily to urban environments, sometimes including environments with a more reduced anthropic impact (Case *et al.*, 1994; Short & Petren, 2008; Zozaya *et al.*, 2015; Cyriac & Umesh, 2021).

Lepidodactylus (Fitzinger, 1843) is one of the genera of geckos with the widest distribution, which currently groups 41 species naturally distributed in southeastern Asia and some Pacific islands (Palacio *et al.*, 2012; Nania *et al.*, 2020; Uetz *et al.*, 2021). Within the genus, *Lepidodactylus lugubris* is the species with the most extensive geographic range, as it has been introduced around the world through human-mediated transoceanic transport (Vitt & Caldwell, 2009; Jiménez & Abarca, 2015; Hoogmoed & Avila-Pires, 2015). *Lepidodactylus lugubris*, commonly known as the mourning gecko, has an extensive capacity for colonization and adaptation in anthropic ecosystems favored by its parthenogenetic reproduction and thermal range of activity between 25 and 35°C (Palacio *et al.*, 2012). Additionally, the species has considerable genetic diversity exhibiting both diploid and triploid populations, each comprising several genetically distinct clones (Ineich, 1999; Yamashiro *et al.*, 2000). Most of these clones exhibit unique patterns of dorsal coloration that permit their identification in the field (Ota, 1994; Ineich, 1999; García *et al.*, 2006; Nania *et al.*, 2020). In general, both diploid and triploid populations coexist throughout their native and introduced ranges (Ineich, 1999; Yamashiro *et al.*, 2000). Most of the populations currently distributed in the Americas have a diploid genetic load (corresponding to clone A sensu Ineich (1999) (Daza *et al.*, 2012). However, triploids (corresponding to clone C) have been reported in Costa Rica and Ecuador. Furthermore, in Colombia, triploid clones C and E have recently been identified for the localities of San Cipriano (Valle del Cauca department) and Barranquilla (Atlántico department), respectively (Palacio-Sierra *et al.*, 2012; Hoogmoed & Ávila-Pires, 2015; Ineich, 2015).

In the Neotropics, *L. lugubris* has been introduced in México, Nicaragua, Costa Rica, Panamá, Colombia, Venezuela, Ecuador, Perú, Brazil, Suriname, Chile, Cuba, and Guadeloupe (French territory) (Krysko *et al.*, 2011; Daza *et al.*, 2012; Montes *et al.*, 2012; Hoogmoed & Avila-Pires, 2015; Bosch & Páez, 2017; Nania *et al.*, 2020; Urra

et al., 2020; Uetz *et al.*, 2021). In Colombia, the species was recorded for the first time in 1941 in the southwestern Pacific lowlands (Daza *et al.*, 2012). Later, its distribution was extended to other parts of the Pacific and Caribbean lowlands (including the islands of San Andrés and Providencia) and Cordilleras Occidental and Central, with an isolated record in the Cordillera Oriental. The current distribution in Colombia comprises 12 departments: Antioquia, Atlántico, Bolívar, Boyacá, Cauca, Chocó, Córdoba, Nariño, Quindío, San Andrés y Providencia, Sucre, and Valle del Cauca (Ayala, 1986; Castro-Herrera & Vargas-Salinas, 2008; Montes *et al.*, 2012; Daza *et al.*, 2012; Vanegas-Guerrero *et al.*, 2016; Mendoza *et al.*, 2018).

Our current knowledge of the distribution of *L. lugubris* in Colombia is exclusively based on specimens deposited in biological collections and reported in the literature (Daza *et al.*, 2012; Vanegas-Guerrero *et al.*, 2016). Thus, it is possible that the current distribution is underestimated, and other sources of data could provide additional localities not yet reported in the literature. Among those alternate data sources, smartphone applications devoted to the documentation of biodiversity now represent an unprecedented amount of information about the distribution of taxa, including introduced species such as *L. lugubris*. For example, the application iNaturalist (iNaturalist, 2021) allows the photographic documentation of species, including amphibians and reptiles, by experts and non-experts while providing strategies to ensure data quality (Jacobs, 2016). Despite this, the potential use of these applications in documenting the geographic distribution of many taxa remains unexplored, and *L. lugubris* is no exception. In this context, our aim was to update and extend the distribution of *L. lugubris* in Colombia based on both previously unreported specimens deposited in herpetological collections and photographic reports compiled from the digital platform iNaturalist.

Materials and methods

To generate an updated map of the distribution of *L. lugubris* in Colombia, we compiled all records of this species available in the literature. Most of these previously published records were compiled and reported by Daza *et al.* (2012), with a few additional reports published since then (Rubio-Rocha *et al.*, 2012; Mendoza *et al.*, 2018). As the geographic coordinates of many of these records were not reported in the literature, we estimated them using Google Earth. To complement these published records, we also examined both previously reported and unreported specimens of *L. lugubris* deposited in the following Colombian herpetological collections: Museo de Historia Natural C.J. Marinkelle at Universidad de Los Andes (ANDES-R; Bogota), Centro de Colecciones Científicas at Universidad del Magdalena (CBUMAG; Santa Marta), the reptile collection of the Instituto de Ciencias Naturales, Universidad Nacional de Colombia (ICN-R and JDL [John D. Lynch field number]; Bogotá), Colección Zoológica de Referencia Científica del Instituto para la Investigación y la Preservación del Patrimonio Cultural y Natural del Valle del Cauca-INCIVA (IMCN; Cali); Colección de Reptiles, Museo de Historia Natural at Universidad de Caldas (MHN-UCa-R; Manizales), Colección de Reptiles, Instituto Amazónico de Investigaciones Científicas-SINCHI (SINCHI-R; Leticia), the herpetological collection at Universidad Industrial de Santander (UIS-R; Bucaramanga).

We also reviewed the records of the species available on the virtual database iNaturalist (iNaturalist, 2021) up to June 13, 2021, where we selected those with photographs allowing species-level identification and with a precise locality. After, we also filtered out localities at more than 5 km away in a straight line from the nearest report of the species (or 1 km for localities on San Andres and Providencia Islands). We followed this course of action to prevent selecting redundant observations in nearby localities. Further, we only selected observations labeled as “Research Grade”, which indicates that two-thirds of the identifiers agree on the same identification for a given observation (Liebgold *et al.*, 2019). Finally, we complemented all the above records with our own photographs of individuals and those taken by colleagues. These specimens came both from localities where the

species has been already reported and from those with no previous reports. For some of these specimens and additional, uncollected individuals from the same localities, we took anecdotal observations of their behavior and habitat use, which we discuss below. For all specimens, we noted the year they were found to determine the date of new records and verify if there are more recent records in the previously known range of *L. lugubris*, which would suggest that such populations have become established.

We identified the specimens deposited in the collections and photographic records based on the diagnostic characteristics including large digital pads, first digits without claw, and basal membranes on digits (Savage, 2002; Hoogmoed & Avila-Pires, 2015). Additionally, whenever possible, we compared the reported specimens with available descriptions of the various distinctive coloration patterns of the clones of the species. These clonal morphotypes differ from each other in the arrangement and shape of the dark markings on the dorsum that they exhibit (Ineich, 1988; Yamashiro *et al.*, 2000).

In general, *L. lugubris* differs from members of the genus *Hemidactylus* because it lacks the claw of the first digit of the hands, in addition to having calcium deposits on the neck that are not observed in the species of this genus (Savage, 2002). Compared to most *Hemidactylus* species reported so far for the Colombian territory (specifically from *H. angulatus*, *H. mabouia*, *H. frenatus*, and *H. palaichthus*), these present an arrangement of dorsolateral tubercles that can be round and flattened, conical and heterogeneous, or conical and trihedral interspersed between the dorsal scales (Avila-Pires, 1995; Cole *et al.*, 2013; Dueñas *et al.*, 2018; Gómez-Martínez *et al.*, 2020; Kluge, 1969; Rösler & Glaw, 2010; Vásquez-Restrepo & Lapwong, 2018) while the dorsum of *L. lugubris* lacks tubercles and is uniformly granular. On the other hand, *H. garnotii* differs from *L. lugubris* in that the second pair of genual scales of the former is not in contact with the infralabial scales (Morales *et al.*, 2017; Vásquez-Restrepo & Lapwong, 2018). As for the genera *Thecadactylus* and *Phyllodactylus* lizards, they also present claws on their five digits, unlike members of the genus *Lepidodactylus*. Additionally, both species of *Thecadactylus* (i.e., *T. rapicauda* and *T. solimoensis*) have extensive webbing on the hands and feet, which is not observed in *L. lugubris* (Bergmann & Russell, 2007), while *Phyllodactylus* differs in having a tuberculate dorsal texture (Ayala & Castro, 1985; Savage, 2002).

Results

Our compilation of historical and previously unreported localities of *L. lugubris* resulted in a total of 89 records, of which 32 were based on collected specimens previously reported in the literature, while 57 represent new records. Of the localities newly reported herein, ten correspond to previously unreported specimens in biological collections and 47 to photographic records, five of which were obtained by us and 42 from the iNaturalist platform, from which we had originally compiled a total of 306 records. However, we had to remove 255 records as they did not meet the cutoff of minimum distance to a previously published locality for the species we had established. Of the remaining 51 records, nine were removed because the lack of an exact locality or the quality of the photographs available prevented us from confirming if they were *L. lugubris*. In general, the new records we compiled allowed us to report for the first time the species for five departments of the country (Caquetá: specimens collected in 2015 and 2021; Cundinamarca: based on iNaturalist observations from 2020 and 2021; Meta: based on iNaturalist observations from 2020; Risaralda: based on iNaturalist observations from 2017, 2020, and 2021, and Santander: photograph taken in 2009 and several specimens found in collections since then) (Figure 1). The new records also indicate that *L. lugubris* is distributed in Colombia between 0 and 2000 m (Table 1S, <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>).

Most records of *L. lugubris* in the country are concentrated in the Andean and Pacific regions, especially near cities and seaports such as Buenaventura, Barranquilla, Cartagena, and Santa Marta. These areas frequently receive elements coming from

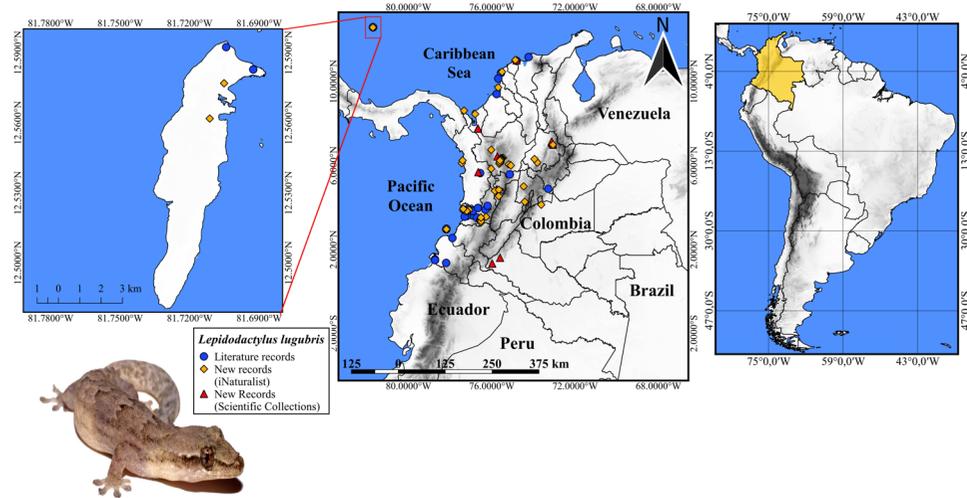


Figure 1. Records of *Lepidodactylus lugubris* in Colombia (blue circles: literature records; yellow circles: new records from iNaturalist; red triangles: new records from scientific collections). Photographs: A. Montes-Correa. The inset map at the left shows San Andrés Island in the Eastern Caribbean Sea.

different parts of the world, facilitating the colonization of *L. lugubris* in Colombia. Additional records of the species found far from Colombia's main seaports appear to be associated with major roads (such as those between the Atlantic Coast and Medellín, those connecting Tumaco or Buenaventura with Cali, and Medellín with Bogotá). This pattern suggests that the dispersal of *L. lugubris* within the country is potentially mediated by road transportation.

Interestingly, populations previously reported for the Pacific Region, the Caribbean coast of the country, and San Andrés Island appear to have subsisted for many years (since 1941, 1991, and 2012, respectively) (**Table 1S**, <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>). Furthermore, most of the new records, except the new departmental records (**Figure 1**), fill gaps between the previous records of the species representing distribution extensions within the same city or between nearby municipalities. However, the new departmental records, except those from the department of Risaralda, represent significant distribution range extensions to the eastern part of the country (i.e., both the western and eastern slopes of the Cordillera Oriental). Also, the records from the southern Atlantic coast and the northern Pacific coast municipalities of Acandí, Necoclí, and Bahía Solano are almost 100 km from the nearest localities reported for the species; they are recent (first records for 2013, 2014, and 2018, respectively) (**Table 1S**, <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>), they correspond to relatively understudied regions of the country.

All the specimens we revised from biological collections and photographs taken by us or obtained from the iNaturalist platform exhibit the dark markings on the dorsum considered characteristic of clone A of the species (**Figure 2**). Finally, anecdotal observations of the individuals we photographed and of others from the same localities suggest that *L. lugubris* tend to be more commonly found close to the sympatric introduced geckos *Hemidactylus frenatus*, *H. angulatus*, and/or *H. mabouia*. Sometimes, both were observed using the same light bulbs to forage and about 2 m from each other. However, it seems there are some slight differences in habitat use. Indeed, *L. lugubris* is less frequently found than *Hemidactylus* and seemingly in the shade and no higher than 1.5 m above the ground. In contrast, species of *Hemidactylus* (as adults) appear to be more commonly found in closer proximity to artificial light sources and at higher parts of walls (>2.5 m). Differences in habitat use seem to be maximized in the locality of Carepa (department of Antioquia),

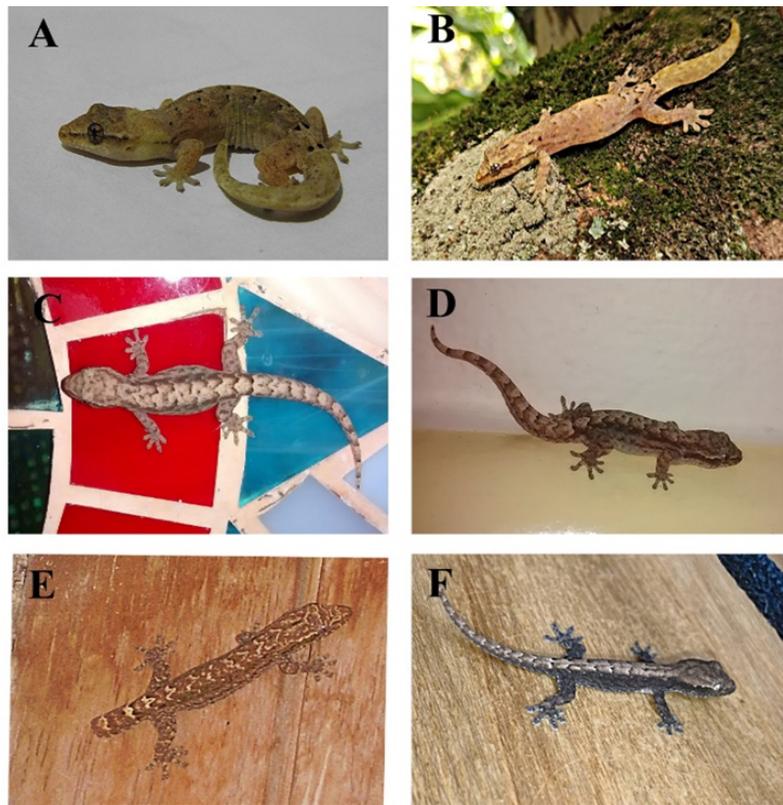


Figure 2. Variation in the color of the morphotype associated with the diploid clone A of *Lepidodactylus lugubris* in Colombia (A: Valle del Cauca - Cali; B: Caquetá - Florencia; C: Antioquia - San Jerónimo; D: Antioquia - San Jerónimo; E: Santander - Bucaramanga; F: Santander - Bucaramanga). Despite the variations, all specimens present the coloration pattern characterized by **Ineich** (1988) for the morphotype associated to clone A (=seven pairs of fine black dots on the dorsum located from the mid-dorsal region to the base of the tail). Photographic credits: A, Daniel Espitia; B, CC and ANM; C-E, JPR; F, Vladimir Quintero

with *L. lugubris* being more commonly found in the external walls of buildings, on nearby boards, and in decaying leaf litter. In contrast, *H. frenatus* was more commonly found on the inner walls of buildings.

Discussion

With the new distribution records for *L. lugubris* reported herein (**Table 1S**, <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>, **figure 1**), the known distribution of the species in Colombia now comprises 17 of the 32 departments of the country. Our new records, along with other recently published range extensions (**Rubio-Rocha et al.**, 2012; **Palacio-Sierra et al.**, 2012; **Montes et al.**, 2012; **Mendoza et al.**, 2018), more than double the number of seven departments reported for the species in the latest summary of its distribution in the country (**Daza et al.**, 2012). Considering that this compilation was published ten years ago, the fact that the known distribution range of the species has grown so much in such a short time span could indicate a very rapid increase in the range extension of *L. lugubris* in Colombia. Alternately, the species could have inhabited at least some localities much earlier than when they were first reported. For example, although *L. lugubris* has been seen in Bucaramanga (department of Santander) since 2009, only here is the species reported for that city. Thus, it is possible that the apparent rapid range expansion of *L. lugubris* in Colombia is an artifact and that the species has inhabited at least some of the newly reported localities for much longer than expected.

Most of our new records concentrate on regions of the country where the species was already reported (the Caribbean, the Western and Central Andes, and the Pacific) (**Daza et al.**, 2012; **Hoogmoed & Avila-Pires**, 2015). Furthermore, our new records from the Gulf of Urabá (municipalities of Carepa and Necoclí) and northern Chocó (municipality of Bahía Solano) support the idea expressed by **Daza et al.** (2012) that the distribution of this species is likely to be continuous between the Pacific and the Caribbean coasts. However, the new localities we report also expand the range of species to the central portion of the western slopes of the Cordillera Oriental and the northwestern edge of the Amazonia and Orinoquia regions of Colombia. Among these new departmental range extensions, two are of particular interest as they correspond to localities found in the transition between the Andean and the Amazon and Orinoquia regions of the country (Caquetá and Meta departments, respectively), areas where the species has not been reported yet. Such findings are worrisome considering that the proximity to these regions would suggest that the species could likely start colonizing them soon if it has not done so already.

Based on these new records, *L. lugubris* now exhibits an altitudinal range from 0 to 2000 m in Colombia (**Table 1S**, <https://www.raccefyfyn.co/index.php/raccefyfyn/article/view/1742/3307>) representing an extension of ca. 500 m from the highest published report for the species (Medellín, Department of Antioquia) (**Rubio-Rocha et al.**, 2013). In other South American countries where this species has been recorded, its altitudinal range reaches up to 900 m: between 7 and 729 m in Ecuador (**Torres-Carvajal**, 2020) and 875 m in Venezuela (**Señaris et al.**, 2017). The elevational limits of *L. lugubris* may be related to the apparent inability of the species to tolerate climatic conditions in areas above ~2000 m. In general, reptiles have difficulties developing ecophysiological processes such as thermoregulation in more temperate or colder environments (**Adolph & Porter**, 1993), thus limiting their ability to feed or reproduce and, thus, their survival (**Meiri et al.**, 2013). The original distribution of the species lies in tropical areas of Asia where the temperature rarely drops below 25°C (**Savage**, 2002; **Lever**, 2003). Ecophysiological studies, as well as additional sampling at altitudes above 2000 m, are needed to better understand the role of temperature and other environmental variables in determining the altitudinal range inhabited by this and other gekkonids in their introduced range and the effect of increasing temperatures and anthropogenic activities on determining the extent of its altitudinal distribution and geographic range in the future. In the future, we may also see situations like that observed for *H. frenatus*, which has maintained its population at 2600 m inside a brewery where the temperature is higher than the ambient temperature of nearby areas (**Caicedo-Portilla & Dulcey-Cala**, 2011).

Lepidodactylus lugubris has a high dispersal capacity, and it is known to have expanded its range to forested environments in parts of its distribution, for example, in Southeastern Asia (**Case et al.**, 1994; **McCoid**, 1996). However, the dependence on urban environments appears to vary between clones, with clone A having lower densities than other clones in forested areas, at least in Hawaii (**Short & Petren**, 2008). In support of this idea, the establishment of *L. lugubris* in South America (where clone A is prevalent) appears to have been limited by the existence of man-made structures (**Hoogmoed & Avila-Pires**, 2015). For example, there are no records from the locality of Macanal (department of Boyacá) since 1981, despite being relatively well-sampled, which is probably a result of the abandonment of human structures in the area (D. Gómez, pers. comm. 2021). Interestingly, Macanal seems to be the only historical locality from which the species seems to have become extinct. Finding this to be the case would suggest that the other populations from previously known sites are likely to have become established and do not correspond to spurious or accidental records as has been reported for other lizards (e.g., the recent finding of *Gymnophthalmus speciosus* at 2000 meters above its normal altitudinal range) (**Henao-Osorio et al.**, 2021). Further sampling is needed to confirm if this is the case and if the presence of human structures limits the distribution of *L. lugubris* on its introduced range or if it can disperse and get established in better-conserved regions.

Lepidodactylus and *Hemidactylus* species can be easily confused (Bosch & Paez, 2017; Bandeira & Missassi, 2022) because they share similar morphological and ethological characteristics, such as the presence of nocturnal habits, inhabiting areas modified by man, and employing foraging strategies associated with artificial light (Case *et al.*, 1994; Savage, 2002). Therefore, these similarities could explain the late reports of *L. lugubris* in some regions (Abarca, 2006). As mentioned above, despite *L. lugubris* inhabiting the city of Bucaramanga since at least 2009, the species has remained unreported there until the present study. Nevertheless, we are aware of specimens collected in this city and deposited in biological collections as early as 2015 that were confused with sympatric species of the genus *Hemidactylus*, which could be the case for other areas and museum collections.

Although our observations are anecdotal, *L. lugubris* seems to be commonly found in sympatry with the introduced gecko *H. frenatus*, a species with which they overlap in much of their distribution where they have been introduced (Rödder *et al.*, 2008). Indeed, it has been observed that both species apparently are involved in resource competition, with *H. frenatus* potentially being able to outcompete *L. lugubris* (Case *et al.*, 1994; Niewiarowski *et al.*, 2012). Further studies on the interspecific interactions between *L. lugubris* and other sympatric geckos in their introduced ranges are needed, as our observations indicate that, at least in Colombia, *H. frenatus* is often more abundant than its counterpart, and it exhibits different substrate use.

The results of our revision of collected specimens and photographic records taken from the iNaturalist platform allow us to conclude that the existence of the morphotype associated with clone A in the Colombian territory is predominant. There is only one record for each of two triploid morphotypes (=C and E) (Hoogmoed & Ávila-Pires, 2015). Such a result supports the idea proposed by Ineich (2015) that clone A reached the American continent before World War II, while the other clones have started to colonize much more recently. However, it is necessary to clarify that identifying specimens of *L. lugubris* at the clone level based on color morphotypes is not ideal, especially when based only on preserved specimens or online photographs (I. Ineich, pers. comm. 2021). Indeed, this should be done by first depositing specimens under complete darkness for an hour, then illuminating them, and their dorsal pattern quickly photographed with the black marks being the only ones retained (I. Ineich, pers. comm. 2021). We recommend future researchers use this protocol to ensure consistency in the methods used to determine clonal morphotypes less ambiguously. In any case, future genetic studies are needed to corroborate the clonal identification of the specimens of *L. lugubris* found in the Colombian territory and in other countries where the species is introduced and to learn more about the geographical origin of the populations and their possible routes of dispersal.

Most of the specimens and new reports of *L. lugubris* recorded for Colombia have been provided by the iNaturalist platform (Table 1S, <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>). That is possible because, in our case, *L. lugubris* has a characteristic pattern of coloration on the dorsum and the absence of the claw on the first pedial digit sometimes can be observed facilitating, in most cases, its identification using good quality photographs. Thus, we highlight the importance of databases such as iNaturalist in providing more detailed and updated knowledge of the distributions of native and introduced species with the help of local communities (Wallace *et al.*, 2019). Although the ideal is to collect specimens and deposit them in registered biological collections, we also recommend, with Auguste & Fifi (2020), to upload observations on various platforms such as iNaturalist with high-quality photographs and precise locality data (with coordinates). Likewise, as suggested by Liebgold *et al.* (2019), observations made on iNaturalist or other citizen science platforms that appear to correspond to distribution extensions should be verified by trained herpetologists.

Supplementary material

View supplementary material in <https://www.raccefyn.co/index.php/raccefyn/article/view/1742/3307>

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Author contributions

Data collection: CC, ANM, JPR, JRCP; data analysis and interpretation: CC, ANM, JPR, JRCP; writing, reviewing, and editing: CC, ANM, DHRV, JPR, JRCP.

Conflicts of interest

The authors declare no conflicts of interest.

References

- Abarca, J. (2006). Gecos caseros (*Hemidactylus*): biología e impacto en Costa Rica. *Revista Mensual sobre la Actualidad Ambiental*, 159, 2-6.
- Adolph, S.C., Porter, W.P. (1993). Temperature, activity, and lizard life histories. *The American Naturalist*, 142, 273-295.
- Aguste, R., Fifi, A. (2020). Additional record of the invasive mourning gecko *Lepidodactylus lugubris* (Duméril and Bibron, 1836) from Trinidad and Tobago, with comments on citizen science observations. *Herpetology Notes*, 13, 1111-1112.
- Arroyave, F. (2015). El tráfico ilegal de reptiles en Colombia: una aplicación del análisis de redes a las relaciones ambientales. Masters dissertation. Universidad Nacional de Colombia.
- Avila-Pires, T. (1995). Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zoologische verhandelingen*, 209, 1-706.
- Ayala, S. (1986). Saurios de Colombia: Lista actualizada y distribución de ejemplares colombianos en los museos. *Caldasia*, 15, 555-575.
- Ayala, S., Castro, F. (1985). Lagartos de Colombia/ Lizards of Colombia. Cali, Colombia: Universidad del Valle and Tulane University International Center for Medical Research.
- Bergmann, P., Russell, A. (2006). Systematics and biogeography of the widespread Neotropical gekkonid genus *Thecadactylus* (Squamata), with the description of a new cryptic species. *Zoological Journal of the Linnean Society*, 149, 339-370. <https://doi.org/10.1111/j.1096-3642.2007.00251.x>
- Bosch, R. A., Páez, R. B. (2017). First record from Cuba of the introduced mourning gecko, *Lepidodactylus lugubris* (Duméril and Bibron, 1836). *BioInvasions Records*, 6(3), 297-300. <https://doi.org/10.3391/bir.2017.6.3.16>
- Brown, S. G., Duffy, P.K. (1992). The effects of egg-laying site, temperature, and salt water on incubation time and hatching success in the gecko *Lepidodactylus lugubris*. *Journal of Herpetology*, 26(4), 510-513. <https://doi.org/10.2307/1565135>
- Case, T. J., Bolger, D. T., Petren, K. (1994). Invasions and Competitive Displacement among House Geckos in the Tropical Pacific. *Ecology*, 75(2), 464-477. <https://doi.org/10.2307/1939550>

- Castaño-Mora, O.** (2002). Libro rojo de reptiles de Colombia. Instituto Humboldt Colombia. Universidad Nacional de Colombia.
- Castro-Herrera, F., Vargas-Salinas, F.** (2008). Anfibios y reptiles en el departamento del Valle del Cauca, Colombia. *Biota Colombiana*, 9(2), 251-277.
- Caicedo-Portilla, R. & Dulcey-Cala, C.** (2011). Distribución del gecko introducido *Hemidactylus frenatus* (Duméril y Bribon 1836) (Squamata: Gekkonidae) en Colombia. *Biota Colombiana*, 12(2), 45-65.
- Cole, C., Townsend, C., Reynolds, R., MacCulloch, R., Lathrop, A.** (2013). Amphibians and reptiles of Guyana, South America: illustrated keys, annotated species accounts, and a biogeographic synopsis. *Proceedings of the Biological Society of Washington*, 125(4), 317-578. <https://doi.org/10.2988/0006-324X-125.4.317>
- Correos, M. C.** (2005). La introducción de especies. Lineamientos generales: ¿Enriquecimiento de la biodiversidad o problemas ecológicos? *Revista Geoespacial*, 2, 64-75.
- Cyriac, V., Umesh, P.** (2021). Natural History of the Gecko *Hemidactylus prashadi*: Demography, Spatial Partitioning, Diet, and Reproduction in a Human-altered Habitat. *Herpetological Conservation and Biology*, 16(2), 325-336.
- Daza, J., Travers, S., Bauer, A.** (2012). New records of the mourning gecko *Lepidodactylus lugubris* (Duméril and Bibron, 1836) (Squamata: Gekkonidae) from Colombia. *Check List*, 8(1), 164-167. <https://doi.org/10.15560/8.1.164>
- Detwiler, J. T., Criscione, C. D.** (2014). Recently introduced invasive geckos quickly reach population genetic equilibrium dynamics. *Biological Invasions*, 16(12), 2653-2667. <https://doi.org/10.1007/s10530-014-0694-1>
- Dueñas, M., Valencia, J., Yáñez-Muñoz, M., Eguiguren, J.** (2018). Primer registro de la salamandrita asiática *Hemidactylus frenatus* Duméril & Bibron, 1834 (Sauria: Gekkonidae) en la Cordillera del Cóndor, Zamora Chinchipe, Ecuador. *Cuadernos de Herpetología*, 2(1), 75-77.
- García, U., Rengifo, J., Moreno, F., Jiménez, A.** (2006). Diversidad de lagartos (Squamata: Lacertilia) en el sotobosque de cuatro localidades asociadas a la cuenca del río Cabi, Chocó – Colombia. *Revista Institucional Universidad Tecnológica del Chocó*, 25, 47-55.
- Gómez-Martínez, M., Gallego-Carmona, C., Castellanos, C.** (2020). Predation of the invasive gecko *Hemidactylus angulatus* Hallowell, 1854 (Squamata: Gekkonidae) by the wandering spider *Ancylometes bogotensis* Keyserling, 1877 (Araneae: Ctenidae) in Tolima, Colombia. *Boletín Científico Centro de Museo de Historia Natural Universidad de Caldas*, 24(2), 65-70. <https://doi.org/10.17151/bccm.2020.24.2.5>
- Henao-Osorio, J. J., Pereira-Ramírez, A. M., Cardona-Giraldo, A., Arias-Monsalve, H. F., Rojas-Morales, J. A., Caicedo-Portilla, J. R., Ramírez-Chaves, H. E.** (2021). On the distribution of three exotic geckos of genus *Hemidactylus* Gray, 1825 (Squamata, Gekkonidae), and an unusual record of the native lizard *Gymnophthalmus speciosus* (Hallowell, 1861) outside its elevational range in Colombia. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 45(175), 462-473. <https://doi.org/10.18257/raccefyn.1356>
- Hoogmoed, M., Ávila-Pires, T.** (2015). *Lepidodactylus lugubris* (Duméril & Bibron 1836) (Reptilia: Gekkonidae), an introduced lizard new for Brazil, with remarks on and correction of its distribution in the New World. *Zootaxa*, 4000(1), 90-110. <https://doi.org/10.11646/zootaxa.4000.1.4>
- iNaturalist** (2021). iNaturalist [online]. Date of access: June 2, 2021. Available from: <https://www.inaturalist.org>.
- Ineich, I.** (1988). Mise en évidence d'un complexe unisexué-bisexué chez le gecko *Lepidodactylus lugubris* (Sauria, Lacertilia) en Polynésie française. *Comptes Rendus Académie des Sciences Paris*, 307, 271-277.
- Ineich, I.** (1999). Spatio-temporal analysis of the unisexual-bisexual *Lepidodactylus lugubris* complex (Reptilia, Gekkonidae). Tropical Island Herpetofauna: Origin, Current Diversity, and Conservation. *Developments in Animal and Veterinary Sciences*, 29, 199-228.
- Jacobs, C.** (2016). Data quality in crowdsourcing for biodiversity research: issues and examples. In: European handbook of crowdsourced geographic information, pp 75-86. Capineri, C., Haklay, M., Huang, H., Antoniu, V., Kettunen, J., Ostermann, F., Purve, R., Eds, Ubiquity Press Ltd. London.
- Jiménez, R., Abarca, J.** (2015). Range and Extension of the Mourning Gecko (*Lepidodactylus lugubris*) in the Caribbean Versant of Costa Rica. *Herpetotropicos*, 10(1-2), 31-32.
- Kolbe, J., VanMiddlesworth, P., Battles, A., Stroud, J., Buffum, B., Forman, R., Losos, J.** (2016). Determinants of spread in an urban landscape by an introduced lizard. *Landscape Ecology*, 31, 1795-1813. <https://doi.org/10.1007/s10980-016-0362-1>

- Kluge, A.** (1969). The Evolution and Geographical Origin of the New World *Hemidactylus mabouia brookii* Complex (Gekkonidae, Sauria). Museum of Zoology, University of Michigan.
- Krysko, K., Burgess, J., Rochford, M., Gillette, C., Cueva, D., Enge, K., Somma, L., Stabile, J., Smith, D., Wasilewski, J., Kieckhefer III, G., Granatosky, M., Nielsen, S.** (2011). Verified non-indigenous amphibians and reptiles in Florida from 1863 through 2010: Outlining the invasion process and identifying invasion pathways and stages. *Zootaxa*, 3028(1), 1-64. <https://doi.org/10.11646/zootaxa.3028.1.1>
- Lever, C.** (2003). Naturalized reptiles and amphibians of the world. Oxford University Press on Demand. London.
- Liebgold, E. B., Liebgold, H. L., Ransom, M. J., Ransom, T. S.** (2019). The spread of the parthenogenetic mourning gecko, *Lepidodactylus lugubris* (Duméril and Bibron, 1836) to Paradise Island, The Bahamas, with comments on citizen science observations of non-native herpetofauna. *BioInvasions Records*, 8(1): 45-49. <https://doi.org/10.3391/bir.2019.8.1.05>
- McCom, M. J.** (1996). Putative interactions of geckos in the southern Mariana Islands. *Micronesica*, 28(2), 193-202.
- Mendoza, J., Gómez-Sánchez, D., Rodríguez, C.** (2018). *Lepidodactylus lugubris* (Asian Mourning Gecko). *Herpetological Review*, 49(2), 286-287.
- Montes, G., Díaz, J., Gaviria, J.** (2012). First Record of *Lepidodactylus lugubris* (Sauria: Gekkonidae) for the Department of Sucre, Colombia. *Revista Colombiana de Ciencia Animal*, 4(1), 163-167. <https://doi.org/10.3897/herpetozoa.33.e53625>
- Morales, R., Chang, M., Acevedo, M.** (2017). First records of *Hemidactylus garnottii* Duméril & Bibron 1836 (Squamata: Gekkonidae) in Guatemala. *Mesoamerican Herpetology*, 4(4), 953-955.
- Nania, D., Flecks, M., Rödder, D.** (2020). Continuous expansion of the geographic range linked to realized niche expansion in the invasive Mourning gecko *Lepidodactylus lugubris* (Duméril & Bibron, 1836). *Plos One*, 15(7), 1-16. <https://doi.org/10.1371/journal.pone.0235060>
- Niewiarowski, P. H., Stark, A., McClung, B., Chambers, B., Sullivan, T.** (2012). Faster but Not Stickier: Invasive House Geckos Can Out-Sprint Resident Mournful Geckos in Moorea, French Polynesia. *Journal of Herpetology*, 46(2), 194-197. <https://doi.org/10.1670/11-148>
- Ota, H.** (1994). Female reproductive cycles in the northernmost populations of the two gekkonid lizards, *Hemidactylus frenatus* and *Lepidodactylus lugubris*. *Ecological Research*, 9, 121-130.
- Palacio, J., Armenta-Gutiérrez, O., Castro-Herrera, F.** (2012). Ampliación del rango de distribución de la salamaneja *Lepidodactylus lugubris* (Duméril & Bibron, 1836) en Colombia. *Herpetotropicos*, 7(1-2), 5-6.
- Rödder, D., Solé, M., Böhme, W.** (2008). Predicting the potential distributions of two alien invasive House geckos (Gekkonidae: *Hemidactylus frenatus*, *Hemidactylus mabouia*). *North-Western Journal of Zoology*, 4(2), 236-246.
- Rösler, H. & Glaw, F.** (2010). Morphologische variation und taxonomie von *Hemidactylus brookii* Gray, 1845 und *Hemidactylus angulatus* Hallowell, 1854 sowie phänotypisch ähnlicher Taxa. *Spixiana*, 33(1), 139-160.
- Rubio-Rocha, L., Alzate, E., Jiménez, C.** (2012). *Lepidodactylus lugubris* (Mourning Gecko). *Herpetological Review*, 43(2), 306-306.
- Savage, J.** (2002). The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. The University of Chicago Press.
- Señaris, C., Rojas-Runjaic, F. J. M., Aristeguieta, M. M., García-Señaris, G.** (2017). Second record of the invasive gecko *Lepidodactylus lugubris* (Duméril & Bibron, 1836) (Squamata: Gekkonidae) from Venezuela. *Check List*, 13 (2), 1-4. <https://doi.org/10.15560/13.2.2082>
- Short, K. H., Petren, K.** (2008). Boldness underlies foraging success of invasive *Lepidodactylus lugubris* geckos in the human landscape. *Animal Behaviour*, 76(2), 429-437. <https://doi.org/10.1016/j.anbehav.2008.04.008>
- Somaweera, R., Yeoh, P. B., Jucker, T., Clarke, R. H., Webber, B. L.** (2020). Historical context, current status and management priorities for introduced Asian house geckos at Ashmore Reef, north-western Australia. *BioInvasions Records*, 9(2), 408-420. <https://doi.org/10.3391/bir.2020.9.2.27>
- Torres-Carvajal, O.** (2015). On the origin of South American populations of the common house gecko (Gekkonidae: *Hemidactylus frenatus*). *NeoBiota*, 27, 69-79. <https://doi.org/10.3897/neobiota.27.5437>
- Torres-Carvajal, O.** (2020). *Lepidodactylus lugubris* In: Torres-Carvajal, O., Pazmiño-Otamendi, G., Ayala-Varela, F. & Salazar-Valenzuela, D. (2021). Reptiles del Ecuador. Version 2021.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. Date of access: April 19, 2021. Available from: <https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Lepidodactylus%20lugubris>.

- Uetz, P., Freed, P., Hošek, J.** (2021). The Reptile Database. Date of access: April 19, 2021. Available from: <http://www.reptile-database.org>.
- Urrea, F., Zúñiga, A., Miranda-Calle, A., Melero, N.** (2020). First record of the invasive gecko, *Lepidodactylus lugubris* Duméril & Bibron, 1836 in mainland Chile (Squamata, Gekkonidae). *Herpetozoa*, 33, 125-129. <https://doi.org/10.3897/herpetozoa.33.e53625>
- Vanegas-Guerrero, J., Fernández, C., Buitrago-González, W., Vargas-Salinas, F.** (2016). Urban remnant forests: Are they important for herpetofaunal conservation in the central Andes of Colombia? *Herpetological Review*, 47, 180-185.
- Vences, M., Wanke, S., Vieites, D., Branch, W., Glaw, F., Meyer, A.** (2004). Natural colonization or introduction? Phylogeographical relationships and morphological differentiation of house geckos (*Hemidactylus*) from Madagascar. *Biological Journal of the Linnean Society*, 83, 115-130.
- Vásquez-Restrepo, D., Lapwong, Y.** (2018). Confirming the presence of a fourth species of non-native house gecko of the genus *Hemidactylus* Oken, 1817 (Squamata, Gekkonidae) in Colombia. *Check List*, 14(4), 665-669. <https://doi.org/10.15560/14.4.665>
- Vitt, L., Caldwell, J.** (2009). *Herpetology: An introductory biology of amphibians and reptiles*. Third Edition. Academic Press, San Diego, California, USA.
- Yamashiro, S., Toda, M., Ota, H.** (2000). Clonal Composition of the Parthenogenetic Gecko, *Lepidodactylus lugubris*, at the Northernmost Extremity of Its Range. *Zoological Science*, 17(7), 1013-1020. <https://doi.org/10.2108/zsj.17.1013>
- Wallace, R., Flores-Turdera, C., Garitano-Zavala, A., Gómez, I., Jurado, C., Maldonado, C., Molina, C., Salinas, E., Torrico, O.** (2019). Reto ciudad naturaleza y naturalista: una oportunidad fantástica para la implementación de la ciencia ciudadana. *Ecología en Bolivia*, 54(2), 67-72.
- Zozaya, S. M., Alford, R. A., Schwarzkopf, L.** (2015). Invasive house geckos are more willing to use artificial lights than are native geckos. *Austral ecology*, 40(8), 982-987. <https://doi.org/10.1111/aec.12287>