

New occurrence records and notes on habitat use and antipredator behavior by *Urostrophus vauitieri* (Squamata: Leiosauridae) in southeastern Brazil

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The Brazilian Steppe Iguana, *Urostrophus vauitieri* Duméril & Bibron, 1837, is a small-sized lizard with cryptic habits and rarely observed in nature, resulting in a lack of information on its natural history (e.g., Sazima and Haddad, 1992; Linares and Eterovick, 2013; Novelli et al., 2013). This insectivorous lizard (Sazima and Haddad, 1992; Novelli et al., 2013) is found in forested environments (Linares and Eterovick, 2013). The species is most often observed using shrubs and the ground for locomotion, foraging (Sazima and Haddad, 1992), and thermoregulation (Gasparini et al., 2010). The lower strata of the vegetation may also be used while resting (Sazima and Haddad, 1992; Henle and Knogge, 2009).

Prior to 2008, *U. vauitieri* was considered endemic to the Atlantic Forest, until the first record of the species was obtained in an enclave of Cerrado in the Atlantic Forest biome, and also in a forest environment in the Cerrado biome (Santos et al., 2009). Currently, the presence of *U. vauitieri* has been confirmed for all states in the southern and southeastern regions of Brazil, with the largest number of records from the Serra do

Mar Corridor, between the states of Rio de Janeiro and Paraná (Santos et al., 2009; Alvares, 2011; SpeciesLink, 2021). However, in the Central Atlantic Forest Corridor, an ecological corridor of major importance that connects remnants of Atlantic Forest from southern Bahia state to southern Espírito Santo State (Lamas et al., 2015; Santana et al., 2020), the species was previously known only from one record in Espírito Santo (Gasparini et al., 2010). Herein we report the occurrence of *U. vauitieri* in the southern portion of Espírito Santo, in the Parque Nacional do Caparaó (PNC), providing new information on its habitat use and antipredator behavior.

Inserted in the Caparaó Massif, the northern region of the Serra da Mantiqueira mountain range, the PNC has an area of approximately 31,800 ha, distributed in the states of Espírito Santo (about 80% of the area) and Minas Gerais (20%) in southeastern Brazil (ICMBio, 2015; Fig. 1). PNC is among the most important remnants of high-elevation Brazilian Atlantic Forest and is the largest and most preserved montane area in Espírito Santo (ICMBio, 2015; Zornosa-Torres et al., 2020). The regional climate is humid subtropical with dry winter and temperate summer, corresponding to Cwb type according to the Köppen Classification (Alvares et al., 2014). The rugged relief of the region, culminating in the Pico da Bandeira (elevation 2892 m), the highest peak in the Atlantic Forest and the third highest peak in Brazil, promotes dynamic climatic conditions (ICMBio, 2015). The average temperature ranges from 19–22°C, with a minimum of –4°C and a maximum of 36°C (ICMBio, 2015). The mean annual rainfall ranges from 1000–1500 mm, but it may exceed 2100 mm during some years (ICMBio, 2015). The region has areas of dense rainforest (montane and high montane), montane seasonal semideciduous forest, high-elevation grasslands, and other ecosystems associated with the Atlantic Forest (ICMBio, 2015). The park's surroundings are mainly occupied by crops and pasture (ICMBio, 2015). Despite the great importance of the PNC for species conservation, studies on local fauna are scarce and needed, especially those related to reptiles

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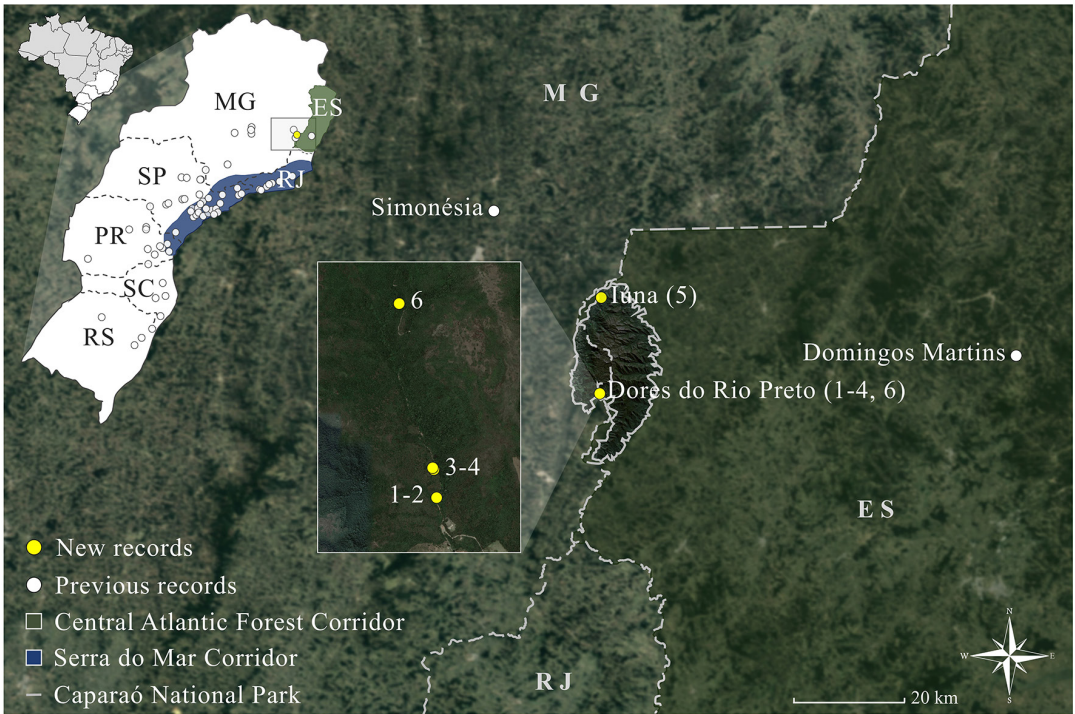


Figure 1. Records of *Urostrophus vautieri* in southern (Paraná - PR, Santa Catarina - SC, Rio Grande do Sul - RS) and southeastern Brazil (Espírito Santo - ES, Minas Gerais - MG, Rio de Janeiro - RJ, São Paulo - SP), with emphasis on the geographical limits of the Central Atlantic Forest Corridor and the Serra do Mar Corridor, and the new records at Caparaó National Park (PNC), Dorés do Rio Preto and Iúna Municipalities, Espírito Santo State. The numbers identify the location of individuals registered in the midwestern and northern portions of the PNC.

(e.g., Valdujo et al., 2007; Rodrigues et al., 2009). Thus, the park is a relevant protected area with a relatively unknown fauna.

The records presented here were obtained on four different occasions, from June–December 2019, in two different locations of the PNC. Upon finding the lizards, we observed and photographed the individuals and characterized their habitats and microhabitats. The geographical coordinates and the elevation at the sites were determined using a GPS (Garmin GPSMAP® 64). Specimens were collected in the field by hand, euthanized by injection with a 5% lidocaine solution, in accordance with the protocols of the Conselho Nacional de Controle de Experimentação Animal (Brasil, 2013), fixed in 10% formalin, and preserved in 70% ethanol. Voucher specimen were deposited in the Zoology Collection of Museu de Biologia Prof. Mello Leitão, Santa Teresa, Espírito Santo, Brazil (MBML), and at the Herpeto Capixaba Collection in the Museum of Natural History of Southern Espírito Santo, at the Federal University of Espírito Santo, Jerônimo Monteiro, Espírito Santo,

Brazil (HC- MUSES).

First encounter. On the first occasion, two *U. vautieri* (Individuals 1 and 2) were observed during the survey of herpetological monitoring at PNC. These two adults (MBML 4755–56) were found at about 14:00 h on 27 June 2019, temperature 16.5°C, near the Beija-flor park housing, which is ca. 200 m distant from the entrance gate of Pedra Menina, in the midwest portion of the PNC, in Dorés do Rio Preto Municipality (Fig. 1). Both individuals were found perched on a *Taquara* bamboo (Poaceae) sharing the same branch. They were lining up on the same stick (which had a diameter similar to their bodies), one close to the other (distant about 15 cm), both positioned with the head facing forwards, with the venter lying against the stick and the limbs placed along the body, at a height of about 3 m above a pond (20.3007°S, 41.4909°W, WGS 84; elevation 1440 m). They remained immobile during our observation that lasted about 5 min; we were at about a 6-m straight-line distance from them. Even when we approached and pulled down the bamboo to capture them by hand,

they remained immobile. However, once captured and handled, they both promptly displayed mouth gape, and one of them bit the collector's finger.

Second encounter. On the second occasion on 20 July 2019, during the same herpetological monitoring at PNC, one juvenile (HC-158; Fig. 2) and another adult *U. vautieri* (HC-159) were found at approximately 14:30 h by active searching (Individuals 3 and 4). They were about 50 m distant from each other, perched in trees along the edge of the park's main road, about 200 m from the previous records (Fig. 1). Both individuals were perched about 3–4 m high, positioned as reported for the two first lizards. We hypothesize that *U. vautieri* assumes this position after the first notice of a potential predator approaching. The individuals were collected and also displayed the mouth gape when hand-captured, also trying to bite the collector.

Third encounter. On the third occasion, one specimen (Individual 5) was recorded during occasional walks along streams, trails, and roads located inside and around the PNC. During this encounter, we performed a non-invasive approach and neither the lizard nor the location were manipulated. This individual was recorded at 11:56 h on 3 November 2019, in a rocky stream located in the northern portion of the PNC (20.3265°S, 41.8095°W, WGS 84; elevation 907 m; Fig. 3A), in Iúna Municipality. The individual was a juvenile and was thermoregulating on a rock in the stream bed (Fig. 3B). The site was not covered by canopy forest and the water flow around the rock was predominantly

laminar. During the observation, the individual jumped into the water and was taken by its flow (on the water surface; Fig. 3C), until climbing another rock about 80 cm from the jump site. The individual was observed for 11 min from its detection to the escape outcome.

Fourth encounter. Lastly, one adult individual was found roadkilled (Individual 6), in December 2019, at approximately 10:00 h on PNC's main road (20.2920°S, 41.4918°W, WGS 84; elevation 1684 m; Fig. 1). This individual was a female with four well-developed eggs, which were expelled through the cloaca when the animal was run over (specimen and eggs not collected).

In addition to our records, the species has now also been recorded for Minas Gerais, in the Simonésia Municipality (SpeciesLink, 2021), located 29 km northwest of our northern record and approximately 44 km from the records made in the midwestern portion of the PNC (Fig. 1). The only previous record in Espírito Santo was in Domingos Martins Municipality, in the surrounding area of Parque Estadual da Pedra Azul (PEPA), in November 2008 (Gasparini et al., 2010), more than 70 km west of the PNC (Fig. 1). It is worth mentioning that our records represent the first records of *U. vautieri* in the Caparaó region and the second site in Espírito Santo. Additionally, the records from PNC and PEPA are the only ones of the species in the Central Atlantic Forest Corridor to date. Due to the scarcity of information, *U. vautieri* is classified as Data Deficient according to the list of threatened species of Espírito Santo (Bérnils et al., 2019).



Figure 2. Juvenile *Urostrophus vautieri* recorded in the midwestern portion of Caparaó National Park, Dores do Rio Preto Municipality, Espírito Santo State, Brazil. Photo by Thiago Silva-Soares.

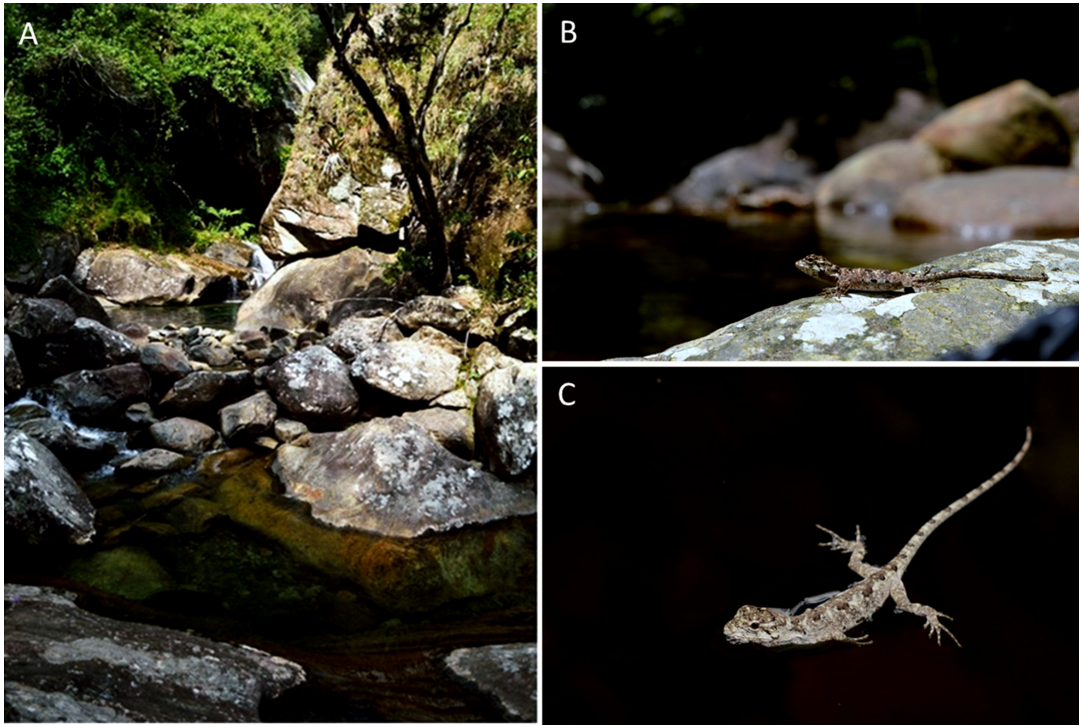


Figure 3. Site in the northern part of Caparaó National Park, Iúna Municipality, Espírito Santo State, Brazil, where we observed a juvenile specimen of *Urostrophus vautieri* (A) on a rock along the edge of a stream (B), and which entered the water and was carried by the water flow (C). Photo by Hilton Entringer Jr.

Distribution models carried out in the southern portion of Brazil (between the states of São Paulo and Rio Grande do Sul) have shown that individuals of *U. vautieri* were mostly associated with rainforest habitats in montane regions (Alvares, 2011). The environmental features of the location where the present records took place are similar to habitat descriptions pointed by Alvares (2011), which may explain its occurrence in the Caparaó region. Likewise, other areas with similar characteristics in Espírito Santo should be investigated regarding the presence of the species to better define its occurrence in the state.

Urostrophus vautieri was recorded thermoregulating on a rock in the PEPA, around 11:00 h (Gasparini et al., 2010), displaying the same behaviour as one of our records. Ectothermic lizards select places with vegetation and substrate that favour thermoregulation and these places are usually represented by clearings and other open areas (e.g., Vitt et al., 1998; Sartorius et al., 1999; Rocha et al., 2009). Given this, watercourses with little vegetation cover and exposed rocks, as observed in the present study, may favour the incidence of radiation and

thermoregulation. Although *U. vautieri* is associated with riparian forest in other localities (Santos et al., 2009; Souza Filho, 2011), this is the first record reporting the use of microhabitats along a watercourse by the species.

The defensive tactics used by *U. vautieri* to avoid predation are poorly known. According to Hudson et al. (2018), the set of antipredator mechanisms presented by *U. vautieri* includes mouth gape (exhibiting oral blue coloration) and bite (both mechanisms displayed here by the four individuals captured), hissing, thanatosis (death feigning), and gular inflation. Herein we include immobility and floating on water to escape as new antipredator behaviors for the species.

Immobility is an antipredator behavior commonly exhibited by lizards (e.g., *Takydromus tachydromoides* – Mori, 1991; *Anolis cristatellus* – Leal et al., 1995; *Takydromus sexlineatus* – Vanhooydonck and Van Damme, 2003; *Pristidactylus achalensis* – Torres et al., 2021). In general, this behavior may be the first one adopted in the presence of possible threats, reducing the probability of detection by movement-guided predators (Mori, 1991; Leal et al., 1995). The combination of

immobility behavior and camouflage can also reduce the risk of predation by reducing detectability, as observed for *P. achalensis* (Torres et al., 2021), which can also be applied to *U. vautieri*.

The use of water bodies for escape has been documented for several lizard species as an antipredator behavior. While some species escape by diving into the water, such as *Iguana iguana* (Greene et al., 1978) and *Uranoscodon superciliosus* (Campos and Magnusson, 2010), others enter the water, such as *Tropidurus flaviceps* (Vitt and Zani, 1996) and *Tropidophorus grayi* (Cruz and Doering, 2020), or run over the water surface to escape from possible predators, such as *Basiliscus basiliscus* (Rand and Marx, 1967) and *B. plumifrons* (Hsieh, 2003). In general, aquatic environments may favor the escape from predators better than terrestrial environments because the prey can drop directly and quickly into water (Doody et al., 2014). It is also noted that for some lizards, such as *Physignathus lesueurii*, most predators are terrestrial, which can make aquatic environments relatively safer and this can lead the development of this antipredator behavior (Doody et al., 2014). The ability to float was previously documented, for example, for *Anolis sagrei* as a dispersion strategy (Schoener and Schoener, 1984), but not as an antipredator behavior.

According to Vanhooydonck and Van Damme (2003), antipredator behavior can vary between habitats, with open microhabitats associated with escape by making individuals more exposed (such as the location where Individual 5 was observed), while microhabitats with more vegetation promote immobility more frequently because they are more protected (such as where Individuals 1 to 4 were encountered), as noted for lacertid lizards. Thus, it is suggested that the differentiated habitat structure may also have influenced the type of antipredator responses by *U. vautieri* in the PNC.

The present records expand the distribution of *U. vautieri* in Espírito Santo, being the first record of the species in the PNC, and contribute with additional information on the habitat use and antipredator behavior of this lizard. Studies on the fauna of PNC are scarce and our contribution demonstrates that additional information about the local fauna, including rare or hardly observed species, may be obtained with more effort in field work. We recommended carrying out species inventories in this region that have great potential to have high species richness and endemism.

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