

Further introductions and population establishment of *Hemidactylus turcicus* (Linnaeus, 1758) in Serbia (Squamata: Gekkonidae)

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Hemidactylus turcicus (Linnaeus, 1758), commonly known as the Turkish Gecko or Mediterranean House Gecko, is a small, predominantly nocturnal gecko that is natively widespread all along the Mediterranean coastline in southern Europe, North Africa and western Asia (Speybroeck et al., 2016). It is very adaptable and often common in anthropogenic habitats, even in urban zones, where it frequently enters buildings (Agasyan et al., 2009; Speybroeck et al., 2016). The species is known as one of the most successful colonisers in the animal kingdom, with populations established throughout the world, throughout places with Mediterranean or tropical climate – southern parts of the United States of America (Stejneger, 1922; Conant and Collins, 1991), Canary Islands, Cuba, Mexico, Panama and Puerto Rico (Agasyan et al., 2009). Since geckos are such adept colonisers, it is hypothesised that many populations of *Hemidactylus*, *Mediodactylus* and *Tarentola* in the Mediterranean basin are of anthropogenic origin (Harris et al., 2004; Kasapidis et al., 2005). Although *H. turcicus* is considered to be expanding (Nelson and Carrey, 1993), it is often restricted to anthropogenic habitats, and its further spread is limited by climate (Meshaka et al., 2005).

Although present in some neighbouring countries – Croatia (Jelić et al., 2012), Montenegro (Ljubisavljević et al., 2018) and Bosnia and Herzegovina (Šukalo et al., 2020) – *H. turcicus* is considered non-native in Serbia, due to its land-locked status and the predominantly continental climate of the country. Thus far, the single report of this gecko in Serbia, in Čelarevo village, Bačka Palanka, was considered as an incidental introduction (Urošević et al., 2016). We thus reviewed known cases of *H. turcicus* records in Serbia to assess the possible population establishment of the species within the country.

The presence of *H. turcicus* was detected by author's personal observations or through citizen science data from the social network (Facebook) that could be positively confirmed by the authors, for which a voucher photo and details of the location and finding were required. Due to the data privacy of the third parties involved, voucher photos are available from the corresponding author upon request. During the authors' field survey, the animals were visually identified, and geographic coordinates were taken (via SaveLocationGPS application for Android; v. 8.0, Rayo Innovations Private Limited). When possible, animals were captured by hand for examination, photographed, and a tail tip for possible further DNA analyses was collected. The presence of immature (subadult or juvenile) animals was noted as a proof of reproduction at the site.

The reports of citizen scientists provided reliable data on incidental findings of *H. turcicus* in the town of Senta (Bačka) in July 2020 and Niš (eastern Serbia) in June 2022 (Table 1). The single gecko in Senta was found in a yard of a private house, while the animal in Niš was noticed on a wall of an underground passage in a shopping mall. During late August 2022, we conducted a field survey in Belgrade for *M. kotschy* and detected presence of *H. turcicus* late in the evening

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Table 1. List of findings of *Hemidactylus turcicus* in Serbia.

Locality	Locality details	Latitude	Longitude	Date	Legator/Reference
Bačka Palanka	Čelarevo v., brewery	45.2746°N	19.5196°E	22 October 2014	Urošević et al., 2016
Senta	Vojislava Ilića st.	45.9302°N	20.0896°E	1 July 2020	Vlašić, A.
Niš	Obrenovićeva st.	43.3196°N	21.8951°E	13 June 2022	Tokić, G.
Belgrade	Senjak, Vojvode Mišića boul.	44.7965°N	20.4436°E	30 August 2022	Urošević, A., Anđelković, M., Maričić, M., Šević, M., Pavlović, J.
Belgrade	Senjak, Vojvode Mišića boul.	44.7961°N	20.4428°E	14 September 2022	Urošević, A., Anđelković, M., Maričić, M., Bosanac, D.

(Table 1, Fig. 1). A total of 11 animals (seven adults and four immatures) were observed during approximately 90 minutes of surveying the walls of a single building block in the Senjak neighbourhood (Savski Venac municipality, Belgrade). The survey was repeated in September, during which a total of eight animals (three adults and five immatures) were observed in 60 minutes (Table 1). The species was identified based on the following diagnostic characters: body translucent, pinkish with irregular blotches and granular scalation, tail pale with crossbands, toes with adhesive pads, with two rows of lamellae and visible claw (Speybroeck et al., 2016). Juvenile animals were noted based on their smaller size (Fig. 2).

The animals were found on both northern and southern exposed walls, in quite humid and shady conditions on the northern walls. They were most often found around or behind gutters, sometimes behind vegetation. The immatures were found around drier, southern exposed walls. About ten of the observed animals had regenerated or missing tails, which suggests predation (by wall lizards or cats) and/or aggressive intraspecific behaviour.

The geckos are documented as very successful colonisers, and in Serbia the spread of *Mediodactylus kotschy* (Steindachner, 1870) into urban habitats is very well documented (Ajtić, 2009; Urošević et al., 2016, 2021). The most likely proposed scenario for their introduction is a series of relatively recent (15–20 years ago), simultaneous introductions into the urban centres (Urošević et al., 2016, 2021).

Prior to 2016, only one report of introduction of *H. turcicus* in Serbia was documented (Urošević et al., 2016). The increased number of findings during the past two years suggests that colonisation is currently ongoing, and that more reports of this species can be expected in the future. It should be noted that both gecko species introduced in Serbia are usually overlooked by the general public. The people whom we interviewed at the known localities are completely unaware of their presence. Until further study, findings

in Senta and Niš can be regarded as incidental findings of single individuals. However, the relatively large number of individuals found in Belgrade, together with the consistent finding of immatures, is indicative of population establishment. *Hemidactylus turcicus* has a fast reproductive cycle. Eggs are laid between May and August, and sexual maturity is reached within a year (Meshaka, 1995) at a snout-vent length of 44–45 mm (Selcer, 1986). Females can lay up to three clutches per season (Speybroeck et al., 2016). The detection of immatures at the site likely results from reproduction in the same year.

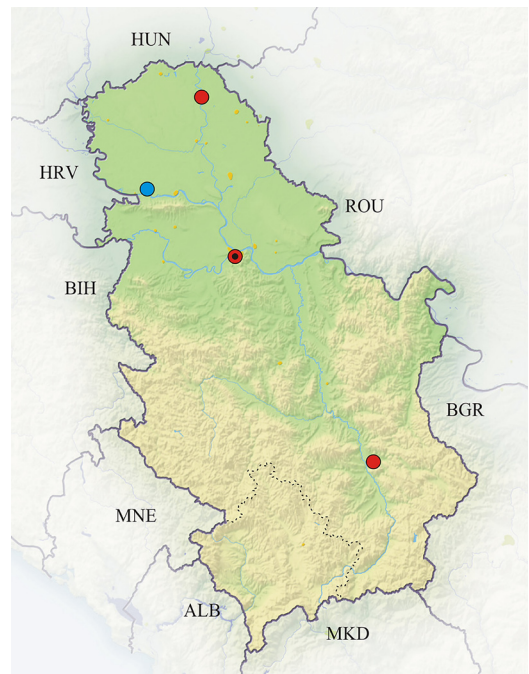


Figure 1. Map of findings of *Hemidactylus turcicus* in Serbia. The blue dot shows the previously documented locality in Bačka Palanka (Urošević et al., 2016). Red dots present new documented localities, with the black dot indicating evidence of successful reproduction.

Hemidactylus turcicus is a species that is naturally strongly associated with the Mediterranean habitats, and

the climate is one of the main factors that can limit its spread (Meshaka, 2005). However, there are indications of population establishment in temperate climatic zones, likely helped by the heating of the interior of the buildings (Norden and Norden, 1991; Locey and Stone, 2006; Stabler et al., 2011).

The species is known for being synanthropic even in its native range and penetrating large towns (Arnold and Ovenden, 2002). The introduced populations are almost exclusively tied to anthropogenic structures (Nelson and Carey, 1993; Meshaka, 1995; Punzo, 2001). Besides the warmth due to winter heating and a “heat island effect”, urban environments also provide artificial light which attracts insects on which the geckos feed (Conant and Collins, 1991; Capula and Luiselli, 1994; Saenz, 1996).

The locality at which *H. turcicus* was detected in Belgrade, a block of buildings in the Senjak neighbourhood, is situated very close to the transportation infrastructure; there is a railroad bridge nearby, and the buildings are right across the Belgrade Fair complex, an important trading zone. Busses that carry organised tourist groups to the holiday resorts in Northern Greece were, for years, departing from and arriving at the Belgrade Fair. Thus, making it a very likely source of introduction. There is also a possible scenario of the intentional release by the enthusiasts, or escapes from the terraria.

In the parts of the Balkan Peninsula where *H. turcicus* and *M. kotschy* come into contact, these two species are often found in syntopy (Speybroeck et al., 2016). Thus, the places in Serbia where *M. kotschy* was successfully introduced could also provide a suitable habitat for *H. turcicus*.

Like *M. kotschy* (Urošević et al., 2016, 2021), *H. turcicus* is not expected to spread outside of urban or anthropogenically modified environments. However, with climate change in mind, the further spread of the species should be monitored throughout Serbia. All sites where *H. turcicus* was reported should be checked for a possible reproduction. Also, the urban population should be better educated about gecko introductions, while encouraging people to get involved with citizen science programs, and to report further gecko observations. Education would also prevent people from bringing live animals with them as the “living souvenirs” from the vacations and releasing them into the environment at home.

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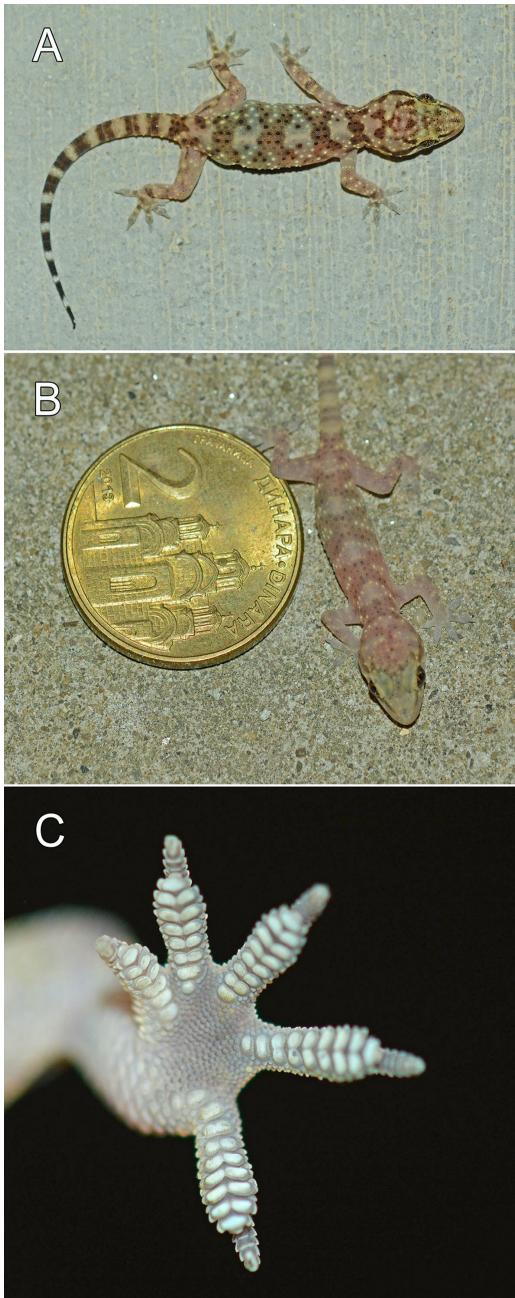


Figure 2. Voucher photographs of the *Hemidactylus turcicus* individuals from Belgrade: (A) an adult animal *in situ*; (B) a juvenile individual with a 2 RSD coin ($d = 21.90$ mm) as a size reference; (C) a close up of toes with the adhesive pads. Photographs by Aleksandar M. Urošević.

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