

Note on the further spread of the Kotschy's Gecko (*Mediodactylus kotschy*) in Serbia with pholidosis description

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Mediodactylus kotschy (Steindachner, 1870) is a small, slender gecko native to the eastern Mediterranean basin (Speybroeck et al., 2016). Kotsakiozi et al. (2018) showed that previously regarded *M. kotschy* is a species complex consisting of five species (*M. kotschy*, *M. orientalis*, *M. danilewskii*, *M. bartoni* and *M. oertzeni*). The newly described species broadly correspond to the main groups defined by Beutler (1981) that can be distinguished based on morphological characters (Ajtić, 2014).

Mediodactylus kotschy (s.l.) is known as a successful colonizer outside its native range in Italy, Hungary, Romania, Bulgaria and Serbia (see Urošević et al., 2021 and references therein). In Serbia, the species is considered native to Prizren, Metohija, where it occurs in several parts of the city (Ajtić and Tomović, 2001). Prizren is exposed to the influence of the Mediterranean climate along the Drim River valley and its tributary (Bistrica). Although the occurrence of the Kotschy's Gecko generally corresponds to the distribution patterns of other Mediterranean herpetofauna species in the region (Haxhiu, 1998; Ajtić and Tomović, 2001; Ajtić, 2004), it seems to be absent from the inland parts of the Drim River valley (Mizsei et al., 2017) which makes this population isolated. All other finds of the species in Serbia are considered as recent introductions (Ajtić, 2009, 2014; Urošević et al., 2016, 2021). One

of the proposed scenarios for their introduction was a historic spread via trade routes and caravans (Ajtić, 2009, 2014). Another proposed scenario is a series of recent, simultaneous introductions into the urban hubs (Urošević et al., 2016, 2021) as Kotschy's Gecko can quickly establish a breeding population (Farkas et al., 1999). A likely path of introduction was also cargo or passenger transport (Urošević, 2016), with railroads suggested as the most probable way of introduction (Urošević et al., 2021). Railroad embankments are often exposed to direct sunlight, provide shelter and prey and can be migratory corridors or even habitats for introduced reptiles (Gherghel et al., 2009; Van Doorn et al., 2021).

In the last few years, we collected data on new populations through social network platforms (e.g., Facebook) that facilitate citizen science. During the summer and fall of 2022, we conducted fieldwork to search for this species mostly in the late afternoon or the early evening hours. We conducted field research on known introductions of the Kotschy's Gecko in Serbia to reconfirm their presence – Zemun (12 July 2022), Pančevo (8 August 2022), Belgrade – Senjak (30 August 2022), Belgrade – Savski venac (14 September 2022), and Smederevo – Fortress (23 September 2022), and we visited two new sites reported through the citizen science approach. We also accounted for all localities visited during 2020 and 2021 as confirmed if the geckos were spotted and collected there (Urošević et al., 2021). After visual confirmation of the presence of animals, the locations were georeferenced (using the SaveLocationGPS application for Android; v. 8.0, Rayo Innovations Private Limited). Animals were collected by hand and photographed with a digital camera (Nikon D7100, Micro Nikkor 85mm F/3.5 ED VR, Nikon Corporation, Tokyo, Japan) from the dorsal side (total body), lateral side (close-up of the head) and ventral side (close-up of cloaca and tail base) to examine pholidosis. A tissue sample (a small part of the tail tip) was collected from each captured

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individual for future DNA analyses not included in this note. After photographing and collecting samples, animals were released at the capture site.

We compared pholidosis with the diagnostic features of the previously described *M. kotschyi* subspecies (Biserkov et al., 2007; Ajtić, 2014). Assuming that the introduction occurred via continental routes, we specifically examined some traits (layout of the otic tubercles and number of preanal pores) diagnostic for the subspecies native to the continental part of the Balkans – *M. k. bibroni* (Beutler & Gruber, 1977), *M. k. skopjensis* (Karaman, 1965), *M. k. rumelicus* (Müller, 1940) and *M. k. danilewskii* (Strauch, 1887). The examined meristic traits were: number of rows of the dorsal tubercles, shape of the dorsal tubercles, layout of the tubercles around the ear opening (otic tubercles), number of supralabials and infralabials, number of preanal pores, and number of lateral caudal tubercles (Fig. 1).

During the field trips, we reconfirmed presence of the Kotschy's Gecko at the localities already reported before in the literature (Fig. 2A). The only locality where the presence was not reconfirmed was Belgrade – Senjak (Fig. 2A), but there we detected the presence of *Hemidactylus turcicus* Linnaeus, 1758 (Urošević et al., 2023). We also gathered new locality data from citizen science approach for: Belgrade – Batajnica (44.8987°N, 20.2738°E, 78 m elevation), Belgrade – Kotež (44.8524°N, 20.4751°E, 72 m elevation), Negotin – center (44.2290°N, 22.5327°E, 44 m elevation) and Leskovac – Farmer's market (42.9991°N, 21.9421°E, 228 m elevation) (Fig. 2A). Of the new localities, we visited Negotin (19 October 2022) and Leskovac (20 October 2022) where we confirmed the presence of the geckos (Fig. 2A). As in previous cases, the geckos were mostly found on walls or buildings, often seen near crevices or objects they can use for shelter such as gutters (Fig. 2B, C). In Negotin, all observed individuals were juveniles or subadults, indicating a reproducing population, while in Leskovac two adult animals were spotted (however, pictures sent to us by the citizens included juveniles as well). Most geckos were localised on the exact buildings they were found for the first time, but in some cases (Belgrade – Savski venac, Zemun, and Sremska Mitrovica) they spread throughout the entire neighbourhoods.

The pholidosis characters of the 22 analysed individuals (16 adults and six subadults) are presented in Table 1. The number of rows of dorsolateral tubercles varied from 11 to 13 (most individuals had 12). The

number of supralabial scales varied between seven and nine and sublabial scales between six and eight. The number of caudal tubercles was two or three. Males had four to six preanal pores, four in most cases (five and six in only one case each). All individuals had large and keeled dorsal tubercles, and otic tubercles were positioned anterior and superior to the ear opening. These meristic and qualitative characters are interpretable as diagnostic for the subspecies already identified in the region of the southern and central

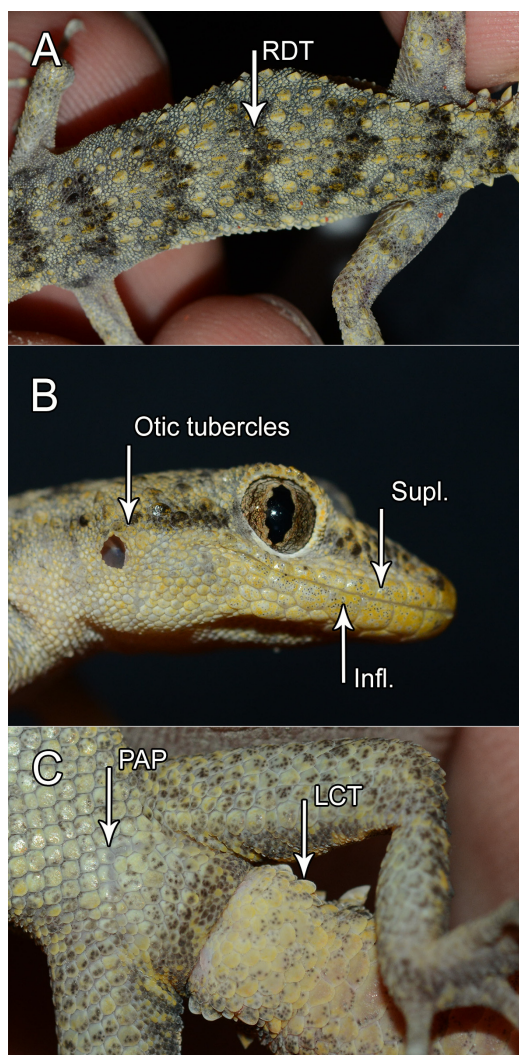


Figure 1. Meristic data: (A) RDT – number of rows of dorsal tubercles; (B) Supl. – number of supralabial scales; Infl. – number of infralabial scales; Otic tubercles – arrangement; (C) PAP – number of preanal pores; LCT – number of lateral caudal tubercles. Photographs by Aleksandar Urošević.

Balkans, *M. kotschy bibrani* (Biserkov et al., 2007; Ajtić, 2014) which geographically matches with the *M. kotschy* species according to the molecular data (Kotsakiozi et al., 2018). This also corresponds with the previous study done on individuals from Niš and Sremska Mitrovica (Urošević et al., 2021).

With our recent work and compared to previous ones (Urošević et al., 2016, 2021), we can assume that the number of introductions in Serbia is increasing, and that further cases can be expected in practically any urban habitats, which we plan to monitor in the future. Also, the recent finding of another Mediterranean gecko species, *Hemidactylus turcicus* reproducing in Belgrade (at the place where *M. kotschy* was previously reported) and incidentally found at other places (Urošević et al., 2023), is also indicative of how increasing transport and climate change can facilitate the spread of predominantly Mediterranean species

into new habitats. Thanks to the contribution of citizen scientists, a lot of new data has been collected. Future citizen collaboration and participation should be encouraged, as well as public education about geckos, climate change, and introduced species.

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Table 1. Meristic data for the collected individuals. Abbreviations: Ind. ID – individual ID; RDT – number of rows of dorsal tubercles; Supl. – number of supralabial scales; Infl. – number of infralabial scales; PAP – number of preanal pores; LCT – number of lateral caudal tubercles; Subad. – subadult.

Locality	Ind. ID	Sex	RDT	Supl.	Infl.	PAP	LCT	Age
Zemun	ZM001	M	11	9	7	4	3	
Zemun	ZM002	F	12	9	7	/	3	Subad.
Zemun	ZM003	F	13	9	7	/	3	
Zemun	ZM004	M	12	8	6	4	2	
Zemun	ZM005	M	12	9	7	4	3	
Zemun	ZM006	F	11	8	7	/	3	
Zemun	ZM007	F	11	9	7	/	3	
Zemun	ZM008	F	12	8	7	/	3	Subad.
Zemun	ZM009	F	12	9	8	/	2	
Zemun	ZM010	F	12	8	7	/	3	
Zemun	ZM011	F	11	9	7	/	3	
Pančevo	PA001	F	11	9	7	/	2	
Belgrade – Savski Venac	SV001	M	12	8	7	4	3	
Belgrade – Savski Venac	SV002	F	12	9	7	/	3	
Belgrade – Savski Venac	SV003	M	11	9	7	4	3	
Belgrade – Savski Venac	SV004	M	12	8	6	6	3	
Belgrade – Savski Venac	SV005	F	12	8	7	/	3	
Smederevo	SD001	F	13	8	7	/	2	Subad.
Smederevo	SD002	F	12	8	7	/	3	Subad.
Negotin	NG001	F	12	7	6	/	3	Subad.
Negotin	NG002	F	12	9	7	/	3	Subad.
Leskovac	LE001	M	12	8	7	5	3	

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Figure 2. (A) Map of findings of *Mediodactylus kotschyi* in Serbia. Blue dots – reconfirmed literature data. White dots – not reconfirmed literature data. Red dots – new localities gathered by citizen science. Concentric red and black dots – citizen science data confirmed by field work. Large green dot – population at Prizren, considered as native. (B) A typical urban habitat of the introduced geckos (Belgrade, Savski Venac). (C) Sections of walls with gutters and crevices, commonly used as a shelter (Belgrade, Savski Venac). Photographs by Aleksandar Urošević.

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