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MEDITERRANEAN HOUSE GECKO, *HEMIDACTYLUS TURCICUS* (REPTILIA: GEKKONIDAE), HAS ESTABLISHED URBAN POPULATIONS IN CENTRAL EUROPE

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The Mediterranean house gecko inhabits the Mediterranean region of Southern Europe, Northern Africa, and Western Asia, but has been introduced in Northern America, in the United States and Mexico in 2015 and 2016. The species has been reported in 2014 in Serbia and then again from 2020 to 2022 in the same country. Here, we report more scattered findings from Romania and Central Europe: Croatia, Austria, Slovenia, Czechia and Hungary, from 2013 to 2025. In Zagreb, Croatia, the species has a small population established, as continuous records exist from 2013 till today in numerous localities, and with specimens observed throughout the year. On the other hand, records from continental Austria and Romania are known to be recently imported specimens.
Key words: iNaturalist, citizen science, allochtonous species, spreading, Zagreb, Croatia, Romania, Austria, Slovenia, Czechia, Hungary

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Kućni macaklin nastanjuje mediteransku regiju južne Europe, sjeverne Afrike i zapadne Azije, ali je unesen u Sjevernu Ameriku (u Sjedinjene Američke Države i Meksiko) 2015. i 2016. godine. Vrsta je prvi put zabilježena 2014. godine u Srbiji, a zatim ponovno od 2020. do 2022. u istoj zemlji. Ovdje predstavljamo podatke o dodatnim, raštrkanim nalazima iz Rumunjske i središnje Europe: iz Hrvatske, Austrije, Slovenije, Češke i Mađarske, u razdoblju od 2013. do 2025. godine. U Hrvatskoj u Zagrebu postoji mala uspostavljena populacija, što dokazuju opetovani nalazi na više mjesta od 2013. do danas, ali i opažanja jedinki tijekom godine. S druge strane, nalazi iz kontinentalne Austrije odnose se na nedavno unesene jedinke.
Ključne riječi: iNaturalist, građanska znanost, alohtona vrsta, širenje, Zagreb, Hrvatska, Rumunjska, Austrija, Slovenija, Češka, Mađarska

INTRODUCTION

The Mediterranean House Gecko, *Hemidactylus turcicus* (Linnaeus, 1758), also known as Turkish Gecko is a nocturnal, synanthropic species native to the Mediterranean region,

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encompassing Southern Europe, North Africa, and Western Asia (AGASYAN *et al.*, 2009; MORAVEC *et al.*, 2011; BOWLES 2024). Species consists of two main lineages, named '*H. turcicus* A' and '*H. turcicus* B', different in 6 out of 303 bp of the Cytb sequence (2.1%) with Southeastern Europe predominantly inhabited by the 'A' lineage (CARRANZA & ARNOLD, 2006; MORAVEC *et al.*, 2011). Due to human-mediated transport and adaptability to urban environments, the species has successfully expanded its range beyond its native distribution (SPEYBROECK *et al.*, 2018). It has been introduced to various parts of the world, including Northern America, where it has established populations in the USA (e.g., BYERS *et al.*, 2007; TEXAS INVASIVE SPECIES INSTITUTE 2014; RUHE *et al.*, 2019) and Mexico (VILLAVICENCIO *et al*. 2021; GRAJALES *et al.*, 2024). In Southeastern Europe *H. turcicus* was documented in Serbia in 2014, with subsequent records from 2020 to 2022 suggesting possible population establishment in certain localities (UROŠEVIĆ *et al.*, 2022, 2023a). However, reports from other parts of Central Europe remain scarce, and the persistence of these populations is not well understood.

Another Mediterranean gecko species complex, *Mediodactylus* (*kotschyi*) (Steindachner, 1870) (KOTSAKIOZI *et al.*, 2018), has also been reported in Serbia and Hungary, primarily in urban environments (UROŠEVIĆ *et al.*, 2022, 2023b; BABOCSAY, 2025). Unlike *H. turcicus*, which is predominantly nocturnal and often associated with human structures, *M. kotschyi* is more diurnal, preferring rocky habitats and natural outcrops, though it can also be found on buildings (SCHWARZ *et al.*, 2016). In the north of its range, the species becomes more associated with anthropogenic habitats (ARNOLD & OVENDEn, 2002). *Mediodactylus kotschyi* is distinguished from *H. turcicus* by having relatively long toes with no adhesive pads. It is also smaller, rarely exceeding 10 cm in length, while *H. turcicus* grows to 12 cm (SPEYBROECK *et al.*, 2018). Given the species complex evolutionary history, multiple lineages may be expected in continental Europe (KOTSAKIOZI *et al.*, 2018).

This study aims to report new records of *H. turcicus* from Central Europe and other parts outside its Mediterranean distribution area with a particular focus on an established population in Zagreb, Croatia. Our findings contribute to the understanding of the species' range expansion and potential for long-term persistence in this region.

MATERIALS AND METHODS

The identification of *Hemidactylus turcicus* (Fig. 1A–B) was based on morphological characteristics that distinguish it from *Mediodactylus kotschyi* (Fig. 1C–D). *Hemidactylus turcicus* is distinguished by having a translucent body with variable coloration, often pinkish,

yellowish or white with irregular dark bands. Scalation of the back is granular with white and brown tubercles. Ventral side of the animal is uniformly white. The tail is slightly flattened and pale with dark cross-bands, particularly visible in juveniles. The toes have adhesive pads, with two rows of lamellae below. Lamellae do not extend to toe tips and the claws are clearly visible (1A). *Mediodactylus kotschyi* (Fig. 1C) is usually pale-grey or grey-brownish in coloration with several dark V-shaped markings with pale edges on the back. Ventral coloration is uniform whitish to orange. The toes are slim and kinked without adhesive pads (Fig. 1D) (ARNOLD & OVENDEN, 2002; SPEYBROECK *et al.*, 2018).

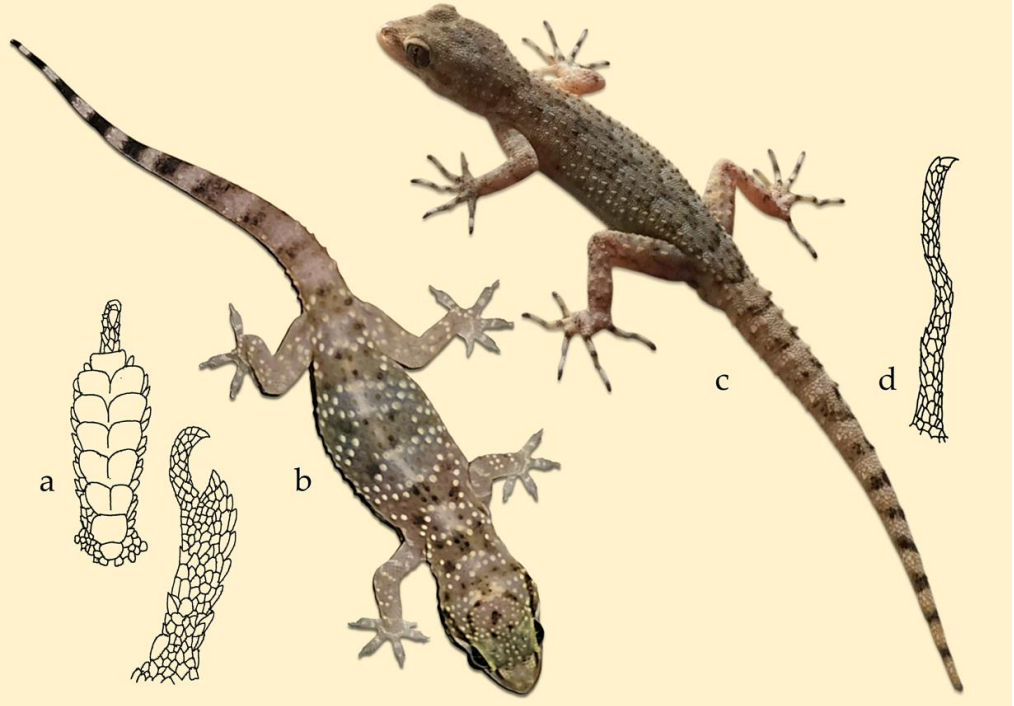

Fig. 1. Comparison of *Hemidactylus turcicus* and *Mediodactylus kotschyi*. a) Lateral and ventral view of *H. turcicus* toe drawn after SPEYBROECK *et al.* (2018); b) Appearance of *H. turcicus* (photo Borna Brezak); c) Appearance of *M. kotschyi* (photo Tikitu de Jager, source iNaturalist, ID 12095360, no copyright); d) Toe of *M. kotschyi* drawn after SPEYBROECK *et al.* (2018).

Observations were collected from iNaturalist, where all available records of the family Gekkonidae from Central Europe were examined and identified to species level. Besides the iNaturalist observations, observations from Biologer platform (POPOVIĆ *et al.*, 2020) were included (obs. Duje Lisičić, Tab. 1). All records were carefully reviewed to verify the species identity, ensuring no misidentifications with other gecko species in the region *(M. kotschyi*). To strengthen the dataset and confirm findings, a group of observers gathered together in this study as coauthors, collaborating to systematically document and verify occurrences of *H. turcicus*. AI tools (CHATGPT, 2025) were used to edit and improve text.

Tab. 1. *Hemidactylus turcicus* (Linnaeus, 1758) observations from continental Europe sorted chronologically. iNaturalist ID of each observation is shown in the last column, except for the observations marked with *, for which Biologer IDs are given. Countries' abbreviations: AUT—Austria, CRO—Croatia, CZE—Czechia, HUN—Hungary, ROM—Romania, SLO—Slovenia.

Date	Country: City: Locality	Coordinates	Observer	ID
2025-VII-26	CRO: Zagreb: Trešnjevka[1]	45.7880N, 15.9390E	Borna Brezak	301050422
2025-VII-15	CRO: Zagreb: Antuna Stipančića[1]	45.7860N, 15.9332E	Marko Ćaleta	302916219
2025-VII-25	HUN: Hódmezővásárhely[1]	46.4202N, 20.3349E	@ifadri	301022122
2025-VI-07	CRO: Zagreb: Trešnjevka[1]	45.7928N, 15.9293E	Borna Brezak	287857898
2025-VI	ROM: Iași: Rediu[2]	47.14N, 27.48E	Alex Strugariu	287111297
2025-V-17	CRO: Zagreb: Trešnjevka[1]	45.7844N, 15.9283E	Borna Brezak	281884500
2024-X-24	CRO: Zagreb: Trešnjevka[1]	45.7865N, 15.9196E	Borna Brezak	249323526
2024-X-06	CRO: Zagreb: Trešnjevka[1]	45.7857N, 15.9205E	Borna Brezak	246074344
2024-IX-09	CRO: Zagreb: Trešnjevka[1]	45.7868N, 15.9201E	Borna Brezak	240669656
2024-IX-04	CRO: Zagreb: Knežija[1]		Maja Lang Balija	-
2024-VIII-28	CRO: Zagreb: Trešnjevka[1]	45.8046N, 15.9656E	Lea Zoretić	238405822
2024-VIII-14	CRO: Zagreb: Gornji Grad[1]	45.8135N, 15.9706E	Mladen Kučinić & Srđan Pichler	-
2024-VIII-07	CRO: Zagreb: Ul. Nikole Škrlca[1]	45.8154N, 16.0033E	@szaza	234394757
2024-VIII	CRO: Prepuštovec[1]	45.90N, 16.13E	Patricia Kokot	236972502
2024-VII-20	CRO: Zagreb: Trešnjevka[1]	45.8089N, 15.9491E	Jakov Dabić	-
2024-VII-08	CRO: Zagreb: Ul. Nikole Škrlca[1]	45.8155N, 16.0032E	@pzf	234394871
2024-VI-26	HUN: Budapest: Petrezselyem ut.	47.5114N, 19.0284E	Marcell Hargitai	229225551
2024-VI-10	CRO: Zagreb: Trešnjevka[1]	45.7864N, 15.9195E	Borna Brezak	221891709
2024-VI-07	CRO: Zagreb: Plemićeva ul. [1]	45.8105N, 15.9918E	Josip Skejo	221319242
2024-I	AUT: Graz: Steiermark[3]	47.06N, 15.40E	Carmen Schuebl	198148498
2023-X-04	CZE: Prague[4]	50.0269N, 14.5270E	Pavel Škaloud	188512312
2022-XII-04	ROM: Bucharest[5]	44.4288N, 26.0312E	Razvan Tilimpea	143644596
2022-I-05	CRO: Zagreb: Trešnjevka[1]	45.8003N, 15.9461E	Patricia Kokot	119885218
2021-VIII-10	CRO: Zagreb: Črnomerec[1]	45.8108N, 15.9489E	Ines Drvar	237828107
2021-IX-01	CRO: Zagreb: Ul. Nikole Škrlca[1]	45.8156N, 16.0037E	Tin Rožman	93233298
2020-X-28	CRO: Zagreb: Ul. Andrije Žaje[1]	45.8072N, 15.9561E	Iva Čupić	-
2020-VII-24	CRO: Zagreb: Ul. Andrije Žaje[1]	45.8072N, 15.9561E	Iva Čupić	-
2020-2021	CRO: Zagreb: Ludbreška ulica[1]	45.8036N, 15.9507E	Duje Lisičić	54859*, 104702*
2020-V-06	SLO: Lipje	46.3570N, 15.1554E	David Kosi	45080572
2015–2025	CRO: Zagreb: Vjekoslava Klaića[1]		Duje Lisičić	214706*
2013–2025	CRO: Zagreb: Mandaličina1	44.8135N, 15.9492E	Marija Ivković	-

[1]On a bulding wall or inside a building; [2]Found in a shopping mall; [3]Found in salad (market); [4]Likely escaped pet; [5]Accidental import from Greece.

Observations of *H. turcicus* in Europe outside Mediterranean are publicly available in iNaturalist at https://www.inaturalist.org/observations?lat=48.67941312108878&lng=19.529375919370594&radius=472.52850172614507&taxon_id=34435 (iNATURALIST, 2025; GBIF, 2025).

RESULTS

Observations of *Hemidactylus turcicus* were recorded in the following Central European countries: Croatia, Hungary, Austria, Czechia, and Slovenia (Fig. 2), but also in Eastern Europe, in Romania. The greatest number of observations comes from Zagreb, Croatia. In Austria it was observed in Graz, in Hungary it was seen in Budapest and in Hódmezővásárhely, in Czechia it was observed in Prague, in Romania in Bucharest and in Ia Iași, and finally in Slovenia it was recorded in Lipje (Tab. 1, Fig. 3). A total of 32 observations were collected, with recorded activity spanning from 2013 till today.

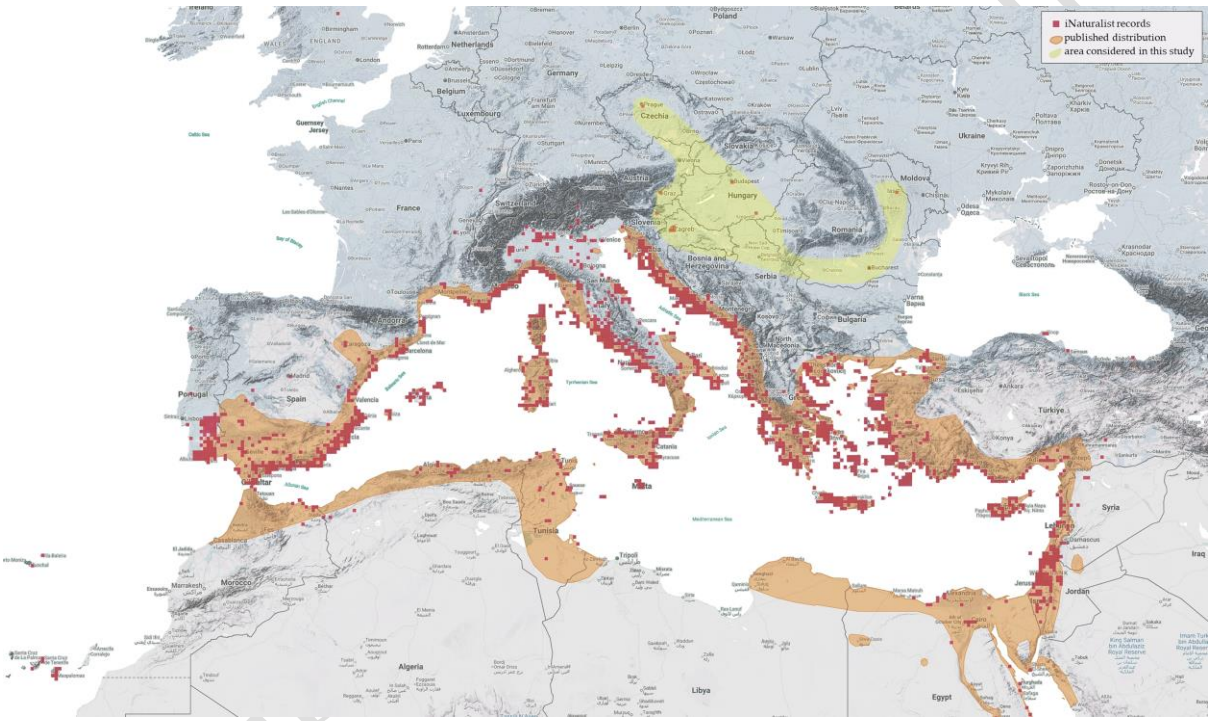

Fig. 2. Native distribution of *Hemidactylus turcicus* in the Mediterranean Basin (orange), overlapped with iNaturalist observations (red squares), and with area discussed in this study in yellow. iNaturalist map available at inaturalist.org/geo_model/34435/explain.

All recorded observations were from urban environments, specifically buildings and their surroundings**.** This suggests that *H. turcicus* outside Mediterranean primarily associates with human structures. In a few observations it was noted that the gecko was found either in a store-bought lettuce (Austria), was accidentally imported (to Romania from Greece), or is likely an escaped pet (Czechia).

An interesting outlier observation, though not directly related to this study, is a record of the Mediterranean house gecko in Brande, Central Denmark, on November 24, 2024**,** documented by Henrik Ploger (iNaturalist ID: 253011219).

Fig. 3. *Hemidactylus turcicus* individuals photographed in continental Europe from 2020 to 2024. a–d) Zagreb, Croatia; e) Graz, Austria; and f) Prague, Czechia. Photographers and numbers of iNaturalist records are denoted under each photograph. a) Photo Patricia Kokot; b) Tin Rožman; c) Borna Brezak; d) Josip Skejo; e) Carmen Schuebl (licence CC-BY-NC); f) Pavel Škaloud (reproduced with permission).

DISCUSSION

The Mediterranean house gecko (*Hemidactylus turcicus*) in Croatia is among the most frequently encountered lizard species in the Adriatic region (iNATURALIST, 2025). However, despite its widespread presence, data on its natural populations, distribution, and ecological dynamics remain limited. Ecology of the introduced American populations seems to be much better understood than in the species' Mediterranean home range (e.g., ROSE & BARBOUR, 1968; DALLAS *et al.*, 2022). Our findings confirm the presence of a synanthropic population in Zagreb established in 2013 or earlier, indicating that this species might be adapted to urban environments of the continental region of Europe, outside its previously documented Mediterranean range. Besides the established populations, our study reports more scattered findings in Romania and Central Europe (Slovenia, Austria, Czechia, Hungary), some of them even evidencing the spreading mechanism.

The scattered nature of these observations suggests that the species' range expansion is more extensive than currently documented. Repeated sightings of individuals in Zagreb over multiple years (Tab. 1) provide strong evidence that this population is not ephemeral but rather established. Besides observing numerous individuals over the years, the strongest evidence of an established population is the observation of individuals of different age stages, from juveniles to adults.

On the other hand, examples similar to the *Hemidactylus turcicus* 'salad' case in Austria (Tab. 1) were already reported in the Caribbean Island of Saint-Barthélemy where *Salamandra salamandra terrestris* (Amphibia: Caudata) was imported from France (iNaturalist observation 192746319), and in a *Lycorma delicatula* (Hemiptera: Fulgoromorpha) whose distribution area include Northeastern USA, but was found to have hitchhiked to Southeastern state of Alabama (iNaturalist ID: 97998348). Such records are not evidence of established populations.

Observations presented in our study (Tab. 1) suggest that *H. turcicus* primarily overwinters within buildings, with multiple individuals observed repeatedly over extended periods. The capacity to persist through winter in artificially heated "Mediterranean" microhabitats is likely a key factor enabling its successful establishment in colder continental regions. Given ongoing climatic changes, it is plausible that *H. turcicus* will continue to expand its range further into Central Europe. Continuous monitoring and further ecological studies will be essential for assessing the broader ecological implications of this expansion on native biodiversity and urban ecosystems.

The expansion of *H. turcicus* and *Mediodactylus kotschyi* more northern into Europe, region previously considered unsuitable for their long-term survival, and the establishment of

their populations provide compelling evidence of ongoing climatic shifts, as already reported in many plant species (SUKOPP & WURZEL, 2003). Rising temperatures are presumably facilitating the overwintering and persistence of these thermophilic reptiles in novel habitats, in the same time harming species adapted to cold (ARAÚJO *et al.*, 2006). This trend is consistent with decreasing range shifts observed in many reptilian and amphibian taxa (HENLE *et al.* 2008), likely driven by global climate change, as exemplified in Italy (D'AMEN & BOMBI, 2009).

Further research is required to elucidate the mechanisms underlying this expansion. Potential pathways of introduction include unintentional human-mediated dispersal, such as transport *via* tourists or imported goods, natural dispersal through urban corridors that provide suitable microhabitat, such as building walls, but also by railway infrastructure (GHERGHEL *et al*. 2009; VAN DOORN *et al.* 2021). Given that most observations in Central Europe originate from urban settings, it is reasonable to hypothesize that *H. turcicus* is utilizing anthropogenic structures as thermal refugia, thereby mitigating the constraints imposed by colder winter temperatures.

Systematic monitoring efforts are imperative to determine whether additional populations in Central European cities exhibit signs of establishment. Citizen science platforms such as iNaturalist have proven instrumental in tracking the spread of many medically relevant species, such as ticks (CULL, 2022), but also invasive species (DIMSON *et al.*, 2023), and here also of allochthonous *H. turcicus*, so we encourage continued data collection from both amateur naturalists and professional herpetologists.

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