

FIRST EVIDENCE OF THE EXPANSION OF *PODARCIS SICULUS* (REPTILIA: SQUAMATA: LACERTIDAE) IN THE PANNONIAN PLAIN, CROATIA

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A newly established population of the Italian wall lizard *Podarcis siculus* has been found in Slavon-ski Brod. The new site is the easternmost habitat of this species in continental Croatia. Anthropogenic habitats and anthropochorous colonisation along with climate change may be the key factors behind the expansion of this species. Due to the expected colonisation of new habitats, genetic lineage identification, population monitoring and risk assessment of further expansion are recommended. A possible colonisation of the southern foothills of the Pannonian mountains poses a potential danger to the local lizard fauna, especially the relict *Ablepharus kitaibelii* population.

Key words: *Podarcis siculus*, population expansion, Croatia

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U Slavonskom Brodu pronađena je novouspostavljena populacija primorske gušterice (*Podarcis siculus*). Novo nalazište predstavlja najistočnije stanište ove vrste u kontinentalnoj Hrvatskoj. Antropogena staništa i antropohorna kolonizacija uz utjecaj klimatskih promjena ključni su za širenje ove vrste. Zbog očekivane kolonizacije novih staništa preporuča se provođenje genetskih analiza i praćenje brojnosti te rasprostranjenosti novih populacija, kao i procjena rizika od daljnjeg širenja. Moguća kolonizacija južnih obronaka Panonskog gorja predstavlja potencijalnu opasnost za lokalnu faunu guštera, posebice reliktnu populaciju vrste *Ablepharus kitaibelii*.

Ključne riječi: *Podarcis siculus*, širenje populacije, Hrvatska

The Italian wall lizard *Podarcis siculus* (Rafinesque-Schmaltz, 1810) is an abundant and widespread lacertid in the Mediterranean region. Pliocene populations were primarily present in the Apennine Peninsula area, from where diversification and colonisation towards the Tuscan archipelago, Sicily, Lampedusa, Sardinia, and Corsica began during the Pleistocene (SENCZUK *et al.*, 2017). Because of its aggressive behaviour (DOWNES & BAUWENS 2002) and ability to adapt rapidly to different dietary resources (HERREL *et al.*, 2008), this species can easily expand to areas populated by other Mediterranean lacertid species. During the Holocene, *P. siculus* at first expanded directly and was later accidentally transported by man from Mt Gargano and Venezia-Gulia

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to the eastern Adriatic coastal belt (PODČAR *et al.*, 2005), resulting in the establishment of populations from Istria along islands and coast to Makarska (Fig. 1A). Southeast of Makarska, only local populations survived after the historical colonisation, likely via trading ships from Calabria to Dubrovnik in Croatia, Kotor in Montenegro (PODČAR *et al.*, 2005), and Albania near Ulcinj (MISZEI *et al.*, 2016). In Dalmatia, this species is distributed along the rivers Zrmanja, Krka and Cetina deep inland to the southern foothills of Mt Poštak and the Dinara Mountains (Fig. 1A). In the Mediterranean region of Croatia, *P. siculus* is an invasive species because of its competitive exclusion of the endemic species *P. melisellensis* (RADOVANOVIĆ, 1965; NEVO *et al.*, 1972) from habitats rich with food and shelter. Combined with their extreme adaptability to open or anthropogenic habitats, this species competes with native species, potentially resulting in a reduction of the distribution area of the latter (DOWNES & BAUWENS, 2002; Vervust *et al.*, 2007). Thus, the presence of *P. siculus* on some small islands together with the complete disappearance of *P. melisellensis* was reported after the *P. siculus* introduction experiment on Pod Mrčaru Islet (NEVO *et al.*, 1972; VERVUST *et al.*, 2009). Furthermore, on Rab Island (86 km²) there was probably the first case of the disappearance of *P. melisellensis* from a larger island (TVRTKOVIĆ *et al.*, 2012) on which both species were present in the past (KRYŠTUFEK & KLETEČKI, 2007).

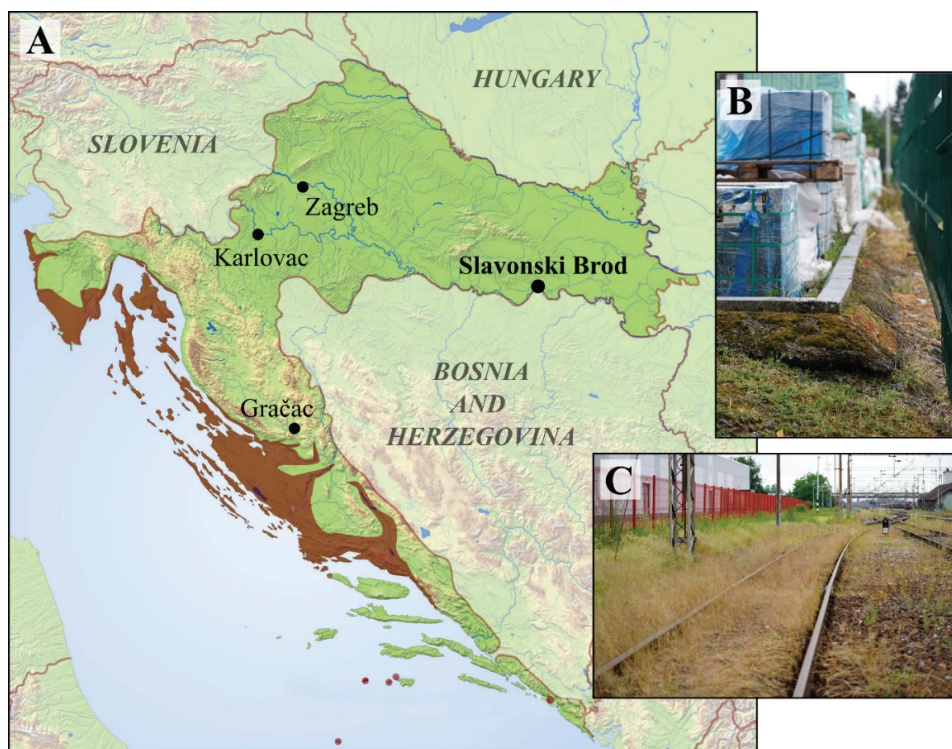


Fig. 1. (A) Distribution of *P. siculus* in Croatia according to KRYŠTUFEK & KLETEČKI (2007) and JELIĆ *et al.* (2016) with older data from Cres Island (TÓTH *et al.*, 2006). Brownish areas represent Mediterranean distribution and black dots localities outside the Mediterranean region. Older data from Cres Island are questionable without confirmation with barcoding. (B) External warehouse of the construction material depot and (C) habitat by the railway line at new site in Slavonski Brod. Photo by M. Kovačević.

Introduced populations are present in locations with similar climates like the South of France, the Iberian Peninsula, the islands of Menorca, Turkey (both sides of the Bosphorus), and North Africa (Tunisia and Libya). Furthermore, populations have been established in several locations across the USA (Philadelphia, Kansas, New York and Los Angeles), Canada (Vancouver), and Russia (SILVA-ROCHA *et al.*, 2012; TUNIYEV *et al.*, 2020; OSKYRKO *et al.*, 2022; BÜLBÜL *et al.*, 2024). Recent introductions have also been reported for northern areas, for example, Belgium, Germany, and Great Britain (HODGKINS, 2012; CLEMENS & ALLAIN, 2021). It is not surprising that recent data imply further expansion to the continental region in Croatia via accidental transportation. Populations have been established in Gračac, Lika County, at a gas station (our observation 2002, last obs. 2013), later in Zagreb, near a railway station (LONČAR, 2005), and Karlovac (JELIĆ *et al.*, 2016, observation of I. Budinski).

Two adult *P. siculus* were accidentally observed on May 13 at a construction material warehouse (Fig. 1A-B) in Slavonski Brod (lat: 45.16199; long: 18.02128). *P. siculus* were observed during basking, and photos of one individual were taken. After confirmation of species identification, the site was re-examined on May 18 (Fig. 2), and the presence of about 100 individuals at different life stages was recorded.



Fig. 2. Adult *P. siculus* observed on 18 May 2024 in Slavonski Brod. Photo by M. Kovačević.

This finding represents the current easternmost population of *P. siculus* in Croatia. The new site consists of the area of a building materials warehouse and part of the area near Slavonski Brod railway station (Fig. 1B, C). The expansion of *P. siculus* may be the result of railway transport as one population is located near a railway station in Zagreb (LONČAR, 2005). In the new site, *P. siculus* once more shows a marked adaptability to anthropogenic habitats and uses cracks under the foundation of the fencing or hides among construction materials. Furthermore, in the area next to the station, juvenile individuals were observed hiding in the holes of field mice and voles. During the first visit, in addition to the two *P. siculus* individuals, a male *P. muralis* was observed. On the second visit, only an adult individual of *Lacerta viridis* was observed, in an area where *P. siculus* was represented in smaller numbers. Considering the negative impact on the native fauna of Mediterranean lizards, it is important to investigate whether this species is equally competitive in the continental region. Moreover, it is important to consider the current status of the species in EU legislation. Namely, *P. siculus* is unfortunately listed in Annex IV of The Habitats Directive and Appendix

II of Convention on the Conservation of European Wildlife and Natural Habitats; although the species is considered to be in Least Concern category in the European Union (ISAILOVIC *et al.*, 2009).

Our observations from Slavonski Brod confirmed that the species can adapt to man-made habitats and the climatic conditions in the Continental region during milder winters and develop new populations. GRBAC & BRNIN (2006) pointed out that *P. siculus* preferred villages, fields, grasslands, shrubs and roadside verges in Mediterranean locations, and we expected this species in similar habitats in Slavonia, the southern part of the Pannonian Plain. Although the effects of introductions are difficult to predict (SILVA ROCHA, *et al.*, 2012; SILVA ROCHA *et al.*, 2014), the further development of trade and transport, accompanied by climate change, could have a positive effect on *P. siculus* expansion. However, due to its invasive nature and the potentially negative impact on native species, it is necessary to start monitoring at known continental localities. Especially dangerous will be possible colonisation of the southern foothills of Pannonian mountains, in particular Papuk Nature Park. The new *P. siculus* population from Slavonski Brod may be a source of future colonization with the worst-case scenario including impact on the population of therelict *Ablepharus kitaibelii*, an endangered species in Croatia (JELIĆ *et al.*, 2016). There are two subpopulations of *A. kitaibelii* located 3 km from Velika, which is directly connected to Slavonski Brod by rail. Therefore, it is recommended population monitoring of new colony and genetically lineage identification. Furthermore, risk assessment of potential expansion is essential in order to determine actions and prevent further expansion of this species.

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