

RARE TIGER BEETLES (COLEOPTERA: CARABIDAE, CICINDELINAE) OF CROATIA: NEW FINDINGS AND CURRENT DISTRIBUTION

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Here we present new records of two rare tiger beetles in Croatia, their distribution and habitat selection. *Cylindera trisignata trisignata* (Dejean, 1822) was recorded in Croatia, for the first time in 115 years, on Mljet Island in Blace Bay. Specimens were collected on a sandy beach, 5–6 m from the water's edge sea coast. *Cylindera arenaria viennensis* (Schrank, 1781) was found in Croatia, for the first time in 67 years, in Podravina, in Kloštar Podravski. It was collected in an area previously exploited for sand mining, which was later abandoned and left to the natural succession. Both species were recorded in rare natural or semi-natural sandy habitat types that are endangered in Croatia. The survival of these and other psammophilous species depends on the suitable management and protection of sandy habitats.

Key words: *Cylindera trisignata trisignata*, *Cylindera arenaria viennensis*, new records, sandy habitats, coastal dunes, sand dunes, embryonic shifting dunes, Pannonic inland dunes

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Ovdje predstavljamo nove nalaze dviju rijetkih vrsta hitri u Hrvatskoj, njihovu rasprostranjenost i opis staništa. *Cylindera trisignata trisignata* (Dejean, 1822) je zabilježena u Hrvatskoj, nakon 115 godina, na otoku Mljetu u zaljevu Blace. Jedinke su sakupljene na pješčanoj plaži, na udaljenosti od 5 do 6 m od mora. *Cylindera arenaria viennensis* (Schrank, 1781) pronađena je u Hrvatskoj, nakon 67 godina, u Podravini u Kloštru Podravskom. Sakupljena je na području koje se prije koristilo za vađenje pijeska i potom prepušteno prirodnoj sukcesiji. Obje vrste hitri zabilježene su na rijetkim prirodnim i poluprirodnim pješčanim stanišnim tipovima koji su ugroženi u Hrvatskoj. Opstanak ovih i drugih psamofilnih vrsta ovisi o odgovarajućem upravljanju i zaštiti tih staništa.

Ključne riječi: *Cylindera trisignata trisignata*, *Cylindera arenaria viennensis*, novi nalazi, pješčana staništa, obalne dune, pješčane dune, embrionske obalne sipine, kontinentalne panonske sipine

Tiger beetles are globally distributed, with the exception of Antarctica, Arctic (north of latitude 65°), and some isolated oceanic islands (PEARSON & VOGLER, 2001). They inhabit various habitat types such as alpine meadows, desert grasslands, sandy beaches and tropical rain forests, and have been recorded at elevations of up to 3,500 m a.s.l. (PEARSON & VOGLER, 2001). Many tiger beetles are habitat specialists and, as such, are widely used as bioindicators (PEARSON & CASSOLA, 1992; RODRÍGUES *et al.*, 1998). Adults are often colourful, highly mobile and daytime ground foragers, while larvae live in

the soil where they dig out narrow burrows. Both adults and larvae prey on other invertebrates (PEARSON & CASSOLA, 1992).

The tiger beetle fauna of Croatia, which is still poorly known, comprises 12 species with several subspecies (BRIGIĆ & VUJČIĆ-KARLO, 2007). However, this statement is derived mainly from older literature (e.g. SCHLOSSER-KLEKOVSKI, 1877; ŠEBIŠANOVIĆ, 1888; LANGHOFFER, 1896, 1913; APFELBECK, 1904; CSIKI, 1946; NOVAK, 1952, 1970; MÜLLER, 1957), findings from museum collections, and a relatively small number recent findings of the authors (BRIGIĆ & VUJČIĆ-KARLO, 2007). The aim of this study is to revise the distribution of *Cylindera trisignata trisignata* (Dejean, 1822) and *Cylindera arenaria viennensis* (Schrank, 1781) in Croatia, based on new findings and old literature data, and to provide further insight on their habitat preferences.

Specimens of *C. trisignata trisignata* and *C. arenaria viennensis* were identified according to HORN (1938), CASSOLA (1973), GEBERT in MÜLLER-MOTZFELD (2006) and LOMPE (2020). Nomenclature follows LÖBL & SMETANA (2003). Voucher specimens are deposited in the first author's collection (University of Zagreb, Faculty of Science, Department of Biology, Croatia) and in the Coleoptera collection of the Hyla Association (Zagreb).

Distribution maps were created in ArcGIS 10.2 (<https://www.arcgis.com/>) using new and literature records. The latter were georeferenced with the locality name and the coordinates of corresponding centroids available at the Gazetteer of Geographical Names of the Republic of Croatia (STATE GEODETIC ADMINISTRATION, 2020).

Cylindera trisignata trisignata

In total, eight specimens of *C. trisignata trisignata* (4 males and 4 females; Fig. 1a) were recorded in the Mediterranean biogeographical region (EEA, 2015), in Blace Bay on Mljet Island (N 42.691165, E 17.743891). Specimens were hand collected on sandy soil on June 15th, 2019. They were found 5 – 6 meters from the water's edge, with the highest activity observed 3 meters from the water (leg. B. Lauš; Fig. 1b). Blace Bay is located in the easternmost part of Mljet Island. It is almost completely isolated and separated from the open sea by a 500 m long and, on average, 50 m wide sandy beach in the centre. The morphology of this stretch of the coastline ensures a relatively low impact of tides, currents and waves. The area is covered by psammophytic vegetation that belongs to the class *Cakiletea maritimae* TX et PRSG 1950, with the frequently present *Cakile maritima* Scop., *Salsola kali* L. and *Euphorbia peplis* L., which are creating a vegetation zone 5 – 16 m distant from the sea. This zone is followed by a zone of a fragmentarily developed *Echinophoro-Elymetum farcti* Gehu 1988 association (ALEGRO et al., 2004). The area, characterised by well-preserved embryonic shifting dunes, has been classified as a Protected Landscape area since 1965 and is included in the NATURA 2000 network (CAEN, 2020). Our findings are in accordance with previous studies stating that *C. trisignata trisignata* inhabits sandy sea beaches and saltmarshes across the Balkan Peninsula (JASKUŁA, 2007; JASKUŁA et al., 2011, 2019).

Our specimens were collected 115 years after the species was first recorded for Croatia, in Zadar (APFELBECK, 1904; Fig 1c). This predominantly West-Mediterranean species is currently divided into five subspecies: *C. t. atlantica* (Barthe, 1922), *C. t. corsica* Rivalier, 1962, *C. t. hellenica* (Cassola, 1973), *C. t. neustria* Rivalier, 1962 and *C. t. siciliensis* (Horn, 1891) (PUTSCKOV & MATALIN, 2003). The presence of *C. t. siciliensis* was recorded for Croatia (MÜLLER, 1926; DEPOLI, 1930; NOVAK, 1952; DROVENIK & PEKS, 1999) on the island of Rab (Lopar beach). As *C. t. siciliensis* occurs only in Italy (Sicily), Mo-

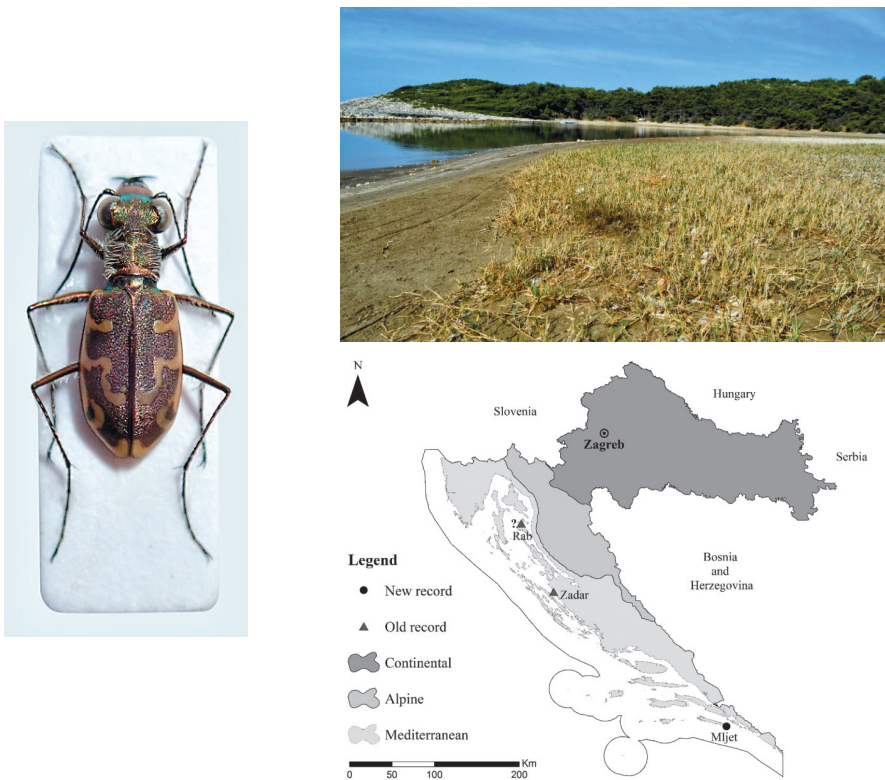


Fig. 1. a) *Cylindera trisignata trisignata* (Dejean, 1822), b) habitat of *C. trisignata trisignata*, sandy beach in Blace Bay, Mljet Island, c) distribution of *C. trisignata trisignata* in Croatia. Legend: ? represents doubtful findings of *C. trisignata siciliensis* (Horn, 1891) from 1983 and/or *C. trisignata arbensis* (Gridelli, 1944) from Rab Island (for details see text).

rocco, Malta, Tunisia, Lybia and Ibiza (WIESNER, 1992; PUTCHKOV & MATALIN, 2003), it is possible that the subspecies from Rab Island was misidentified by G. B. Novak in 1893 (MÜLLER, 1926; not by Petar Novak as stated in JASKUŁA *et al.*, 2005), and the finding was later included in the book “*Kornjaši jadranskog primorja*” written by his son Petar Novak (1952). CASSOLA (1973) excluded *C. t. siciliensis* and reported *C. trisignata arbensis* (Gridelli, 1944) from Rab Island, but this subspecies was later synonymised with the nominal species in PUTCHKOV & MATALIN (2003). *Cylindera t. trisignata* was also reported by MAGISTRETTI (1965) and DROVENIK & PEKS (1999) from Rab Island. Lopar beaches were surveyed in August 2019 and May 2020 to confirm the persistence of *C. t. trisignata*, but without positive results (KOREN & MARČIĆ, personal data). This could possibly be related to the sampling period, seasonal dynamics of the species or to the disturbance caused by tourists. Considering the current knowledge and the lack of data from Rab Island, it is difficult to conclude with certainty which subspecies was found in the area. The matter is further complicated by a drawing of the elytra from HORN (1938), clearly different from the elytra of the nominal species. Nevertheless, taking the known distribution of *C. trisignata* subspecies into consideration (e.g. PUTCHKOV & MATALIN, 2003; JASKUŁA, R., 2007), we regard the occurrence of the nominal species on Rab Island as most likely, but this needs further confirmation by future studies.

Cylindera arenaria viennensis

A total of ten specimens of *C. arenaria viennensis* (4 males and 6 females; Fig. 2a) were recorded in Podravina, Kloštar Podravski (N 46.002701, E 17.170398), in the Continental biogeographical region (EEA, 2015). Specimens were hand collected on sandy soil on August 22nd, 2019 (leg. T. Koren). More specimens were observed at the locality on the same and the following day. In this time frame, several other sandy habitats (e.g. Đurđevački pijesci, sandy banks of the Drava River) were surveyed in search of the species, but no additional specimens were found. *Cylindera a. viennensis* was recorded in an area previously used for sand extraction; the area is nowadays abandoned and under natural succession (Fig. 2b). A water-filled gravel pit, covering an area of 6 m² and surrounded by *Salix* sp., is situated in the vicinity of the sand mining area. This area is characterised by a mosaic of habitats in various stages of succession, from bare sandy soils to young secondary forests. Pannonic inland dunes (h.t. 2340) and Pannonic sand steppes (h.t. 6260) are priority habitat types in the Habitats Directive, and as such are included in NATURA 2000 network (CAEN, 2020). Generally, the vegetation of the Podravina sands belongs to the *Corynephoru-Festucetum vaginatae* Soklić, 1943 association, dominated by psammophilous plants, such as *Corynephorus canescens* (L.) P. Beauv. and

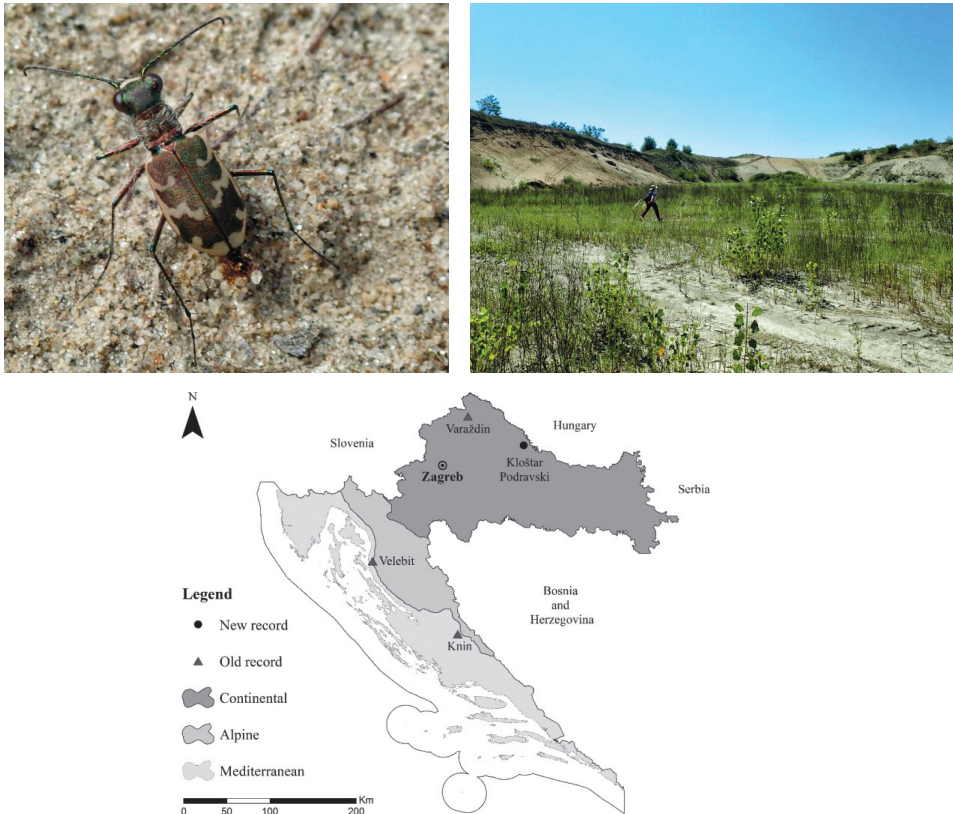


Fig. 2. a) *Cylindera arenaria viennensis* (Schrank, 1781), b) habitat of *C. arenaria viennensis*, abandoned sand extraction site in Kloštar Podravski, Podravina, c) distribution of *C. arenaria viennensis* in Croatia.

Festuca vaginata Willd (SOKLIĆ, 1943). The sand dunes are currently endangered mainly due to vegetation succession (KRANJČEV, 2006). Weeds (e.g. *Ambrosia artemisiifolia* L.) and neophytes (e.g. *Robinia pseudoacacia* L.) are overgrowing the sand dunes, causing changes in vegetation composition and structure. Like other psammophilous species, *C. arenaria viennensis* inhabits the sandy banks of unregulated river reaches (JASKUŁA *et al.*, 2011) and river banks without vegetation (LUKA *et al.*, 2009). Rare psammophilous carabid beetles have almost disappeared from the agricultural landscape in Central Europe. Because of this, gravel pits used as secondary refuges, represent valuable habitats that could ensure the persistence of these rare psammophilous species in the landscape (TRAUTNER, 1996; RŮŽIČKOVÁ & HYKEL, 2019). Consequently, the maintenance of bare sandy habitat patches, which should be protected from succession, is crucial for the survival of rare psammophilous carabid beetles (RŮŽIČKOVÁ & HYKEL, 2019).

Cylindera arenaria arenaria (Füessly, 1775) is distributed predominantly in western Europe, while the subspecies *C. a. viennensis* (Schrank, 1781) occurs from central and eastern Europe, to western Siberia and Lake Baikal (TRAUTNER, 1996; PUTCHKOV & MATALIN, 2003). *Cylindera a. viennensis* is a subspecies present in the Balkan Peninsula (TRAUTNER, 1996; JASKUŁA *et al.*, 2007). Another subspecies, *C. a. nudoscripta* (Horn, 1915), is distributed in Azerbaijan, Armenia, Georgia, South European Territory of Russia and Turkey (PUTCHKOV & MATALIN, 2003), thus it is not expected to occur in Croatia. *Cylindera a. viennensis* was first recorded for Croatia in Varaždin by F. Koščec in 1918 (BREGOVIĆ, 1985). Additionally, it was also found on Velebit Mountain (SCHLOSSER KLEKOVSKI, 1877) and in Knin (NOVAK, 1952). Interestingly, SCHLOSSER KLEKOVSKI (1877) and BREGOVIĆ (1985) reported the findings as *Cicindela litteráta* Sulzer, 1776, a species that was later synonymised with *C. arenaria arenaria* in PUTCHKOV & MATALIN (2003). This report may suggest that the nominal subspecies occurs in Croatia. However, the samples of *C. arenaria* we examined from the Varaždin City Museum, Entomology Collection of F. Koščec (TVCM), correspond to *C. arenaria viennensis*, as already noted by F. Koščec in the Collection, but not included in the BREGOVIĆ (1985) publication. Consequently, according to present knowledge only *C. arenaria viennensis* occurs in Croatia, being distributed in all three biogeographical regions: Continental, Alpine and Mediterranean (TVCM; SCHLOSSER KLEKOVSKI, 1877; NOVAK, 1952; Fig. 2c). Interestingly, *C. arenaria viennensis* was not recorded in recent comprehensive studies by TALLÓSI (2008) along the Croatian part of the Drava River.

The rediscovery of these two species confirms that the carabid beetle fauna of sandy habitats in Croatia needs further study. Sandy sea beaches and saltmarshes are species-rich habitats for Cicindelinae in the Balkan Peninsula (JASKUŁA *et al.*, 2011). However, these habitats are particularly threatened in the Mediterranean region of Europe including the Balkan Peninsula coastline, due to the expansion of tourism and the rapid development of tourism-related infrastructure (e.g. ARNDT *et al.*, 2005). The two new populations of *C. trisignata trisignata* and *C. arenaria viennensis* were located within the Natura 2000 network, in priority habitat types, reinforcing the pressure for the conservation of these areas. Sandy beaches in Croatia are rare, small, and fragmented habitats, which makes them highly endangered (ALEGRO *et al.*, 2004; STANČIĆ *et al.*, 2008; PIKELJ & JURAČIĆ, 2013). The majority of typical sandy coastal plant species in Croatia are included in the Red List (NIKOLIĆ & TOPIĆ, 2005), which makes the conservation value of these habitats even higher. Additionally, rivers and streams in Croatia have been subjected to complete or partial regulation that resulted in the disappearance of many

natural habitats (MRAKOVČIĆ *et al.*, 2006). Natural flow dynamics in floodplains is a prerequisite for *C. arenaria* preservation (TRAUTNER, 1996). Consequently, many tiger beetles are, or could potentially be, threatened in the near future (JASKUŁA *et al.*, 2011), with several species already red-listed around the world (*c.f.* TRAUTNER, 1996; PEARSON & VOGLER, 2001; IRMLER, 2010). Moreover, TRAUTNER (1996) suggested inclusion of *Cylindera arenaria* in the European Habitats and Species Directive (Annex II and IV). Due to their habitat specificity, well known taxonomy, biology and ecology, and charismatic appearance, tiger beetles are globally recognised as flagship species and are used as bioindicators (PEARSON & CASSOLA, 1992, 2007; PEARSON & VOGLER, 2001; ARNDT *et al.*, 2005). Thus, tiger beetles could be used as a leading element of insect conservation campaigns for the broad public in protected areas (e.g. Mljet National Park), with special emphasis given to the conservation of their natural and semi-natural habitats.

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