

Rediscovery of the Dice Snake *Natrix tessellata* (LAURENTI, 1768), from the Island of Krk, Croatia

In spite of its natural occurrence and locally common presence in Croatia, the Dice Snake *Natrix tessellata* (LAURENTI, 1768), is rare or completely absent from along most of its Adriatic coast (JELIĆ & LELO 2011). Crucial factors for the snake's presence in the region were thought to be the availability of freshwater and concurrent fish prey, which are particularly abundant more inland in the Dinarid karsts (e.g., Plitvica lakes, Zrmanja river, Krka river, Baćina lakes, Vrana Lake near Zadar). Thus, because of the scarcity of freshwater systems, previous published occurrences of Dice Snakes on several Croatian islands or other areas along the Adriatic coast were disputed (JELIĆ & LELO 2011). Such literature records for *N. tessellata* refer to the islands of Cres, Krk and Prvić (BRUNO 1980; SOCHUREK 1985; FRANZEN 1987; MRŠIĆ et al. 1989; SCHIMMENTI & FABRIS 2000). Misidentification and intentional introduction were further confusing the autochthony of

N. tessellata inhabiting Croatian Adriatic islands (cf. TÓTH et al. 2006; SCHWEIGER 2008, 2012; JELIĆ & LELO 2011). For example, for the island of Krk there is only one voucher, a photograph of *N. tessellata* taken on April 10, 1985, by the herpetologist Michael FRANZEN (cf. SCHWEIGER 2008, 2012). The latter author suggested that this specimen might be a successor from snakes introduced by a reptilian dealer, who used to release his surplus of unsold north Balkan reptiles on Krk island every fall until the early 1970s. However, regardless of the recent intensive search by many field herpetologists including the authors of this paper, no additional specimen of *N. tessellata* could be found, and thus, this species was no longer considered part of the natural herpetofauna on Krk Island.

Figure 1 shows the positions of all published record localities of *N. tessellata* on Krk Island. These include four sites: Suho Ričina, a watercourse near Baška (Fig. 2B; BRUNO 1980, 1988; SOCHUREK 1985), the Ponikve Dam (Fig. 2C; BRUNO 1980, 1988; SCHIMMENTI & FABRIS 2000), the Jezero Dam (Fig. 2D; BRUNO 1980) and a small marsh near Miholjice south from Njivice in the

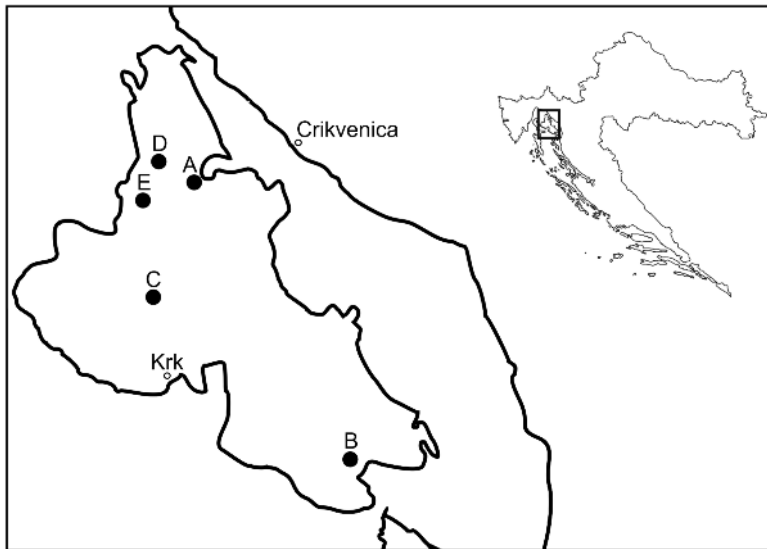


Fig. 1: Outline map of the Island of Krk with all reported locations of findings of *Natrix tessellata* (LAURENTI, 1768). Points A-E relate to the habitat pictures in Fig. 2.

northern part of the island (Fig. 2E; FRANZEN 1987). However, the lack of vouchers, such as live or preserved specimens or photographs to verify species identities for three of those localities generated uncertainty about the accuracy of such information.

SCHIMMENTI & FABRIS (2000) allegedly observed the mating behavior of *N. tessellata* on June 7, 1995, at the Ponikve Dam. They report simultaneous and frequent matings of the Grass Snake *Natrix natrix* (LINNAEUS, 1758), at the same site. The Dice Snake observation might represent a confusion with the *helvetica* morph of the Grass Snake, which superficially resembles *N. tessellata* in its color pattern of gray dorsum with blackish spots. However, the authors were affiliated with institutes (university and public aquarium) that deal with poikilothermic animals including reptiles and originated from a region (Genova, Italy) that is home to both above and one more species of the genus *Natrix*, rendering these observers credible (also confirmed by V. FABRIS, pers. comm.). BRUNO'S (1980) and SOCHUREK'S (1985) reports of *N. tessellata* gain credibility, as both authors are well known experts of reptiles. However, BRUNO (1980) once uttered to intentionally publish wrong localities to promote others to search harder in those areas (cf. SCHWEIGER 2012). But in this case, we have no indication that he has done so with his Dice Snake observation from Krk Island, and hence, include his records on the plausible grounds that (i) suitable habitat is available on the island (pers. obs.), (ii) a few different records from Krk Island made by other authors corroborate his finding, and (iii) there are records of Dice Snakes from other, nearby islands (see below).

On September 28, 2011, at 15:45 h, an adult specimen of *N. tessellata* (TL approx. 60 cm, Fig. 3) was found by one of the authors (MK) in the channelized stream Veli Potok (Fig. 2A) in the north-eastern part of this island. Air temperature was 20 °C. The stream flows into the Gulf of Soline in an area known as Meline, situated between the villages of Čižići and Soline (45.14906 N, 14.59949 E; 0-1 m a. s. l.). The stream bed consists largely of stones, but bank and bed become more muddy upstream of the estuary. The locality is approx. 7 km from the

nearest mainland (Crikvenica), but the island's shortest distance to the mainland is only 0.5 km at its northern tip. The specimen showed a conspicuous pale dorsal ground coloration with dark spots (comp. e.g., JELIĆ & LELO 2011). More precise data about morphometrics and pholidosis was not recorded. After photographic documentation, the specimen was released back to its locality. A subsequent survey of the stream area more than one year later on May 22-24 and June 4, 2013, yielded no additional specimens. Syntopic species of amphibians and reptiles at the locality were: *Pelophylax ridibundus* (PALLAS, 1771), tadpoles of *Bufo bufo* (LINNAEUS, 1758), *Podarcis siculus* (RAFINESQUE-SCHMALTZ, 1810) and *Hierophis gemonensis* (LAURENTI, 1768). The stream was well populated by Mulletts most probably *Mugil cf. cephalus*. The new record of *N. tessellata* on Krk confirms previous reports, thereby increasing the number of snake species of the local herpetofauna to a total of 11 (cf. SCHWEIGER 2004, 2012).

Interpretation of an isolated find of a single specimen is difficult and often speculative. As for the lack of information on a reproductive population (and not just a handful historical records of Dice Snakes), *N. tessellata* may not belong to the permanent fauna of Krk. From an eco-biogeographical point of view, it may be interesting, that similar to *N. tessellata*, the Eastern Montpellier Snake *Malpolon insignitus* (GEOFFROY DE ST-HILAIRE, 1809), occurs on the mainland and on the neighboring Island of Cres (BRUNO 1980; TÓTH et al. 2006), whereas a viable population on Krk was never reliably confirmed. Single specimens observed on that island were classified introduced (SOCHUREK 1985; SCHWEIGER 2012). Surprisingly, a recent field expedition rediscovered three Dice Snakes on the inland freshwater Lake Vrana on Cres Island (BURIĆ & BAŠKIERA in press), indicating the presence of a natural population there.

The origin of the individual reported here from Krk remains unclear and the question about any permanent, reproductive population unanswered. The bright coloration of the new specimen is typical to Dice Snakes from along the northern Dal-

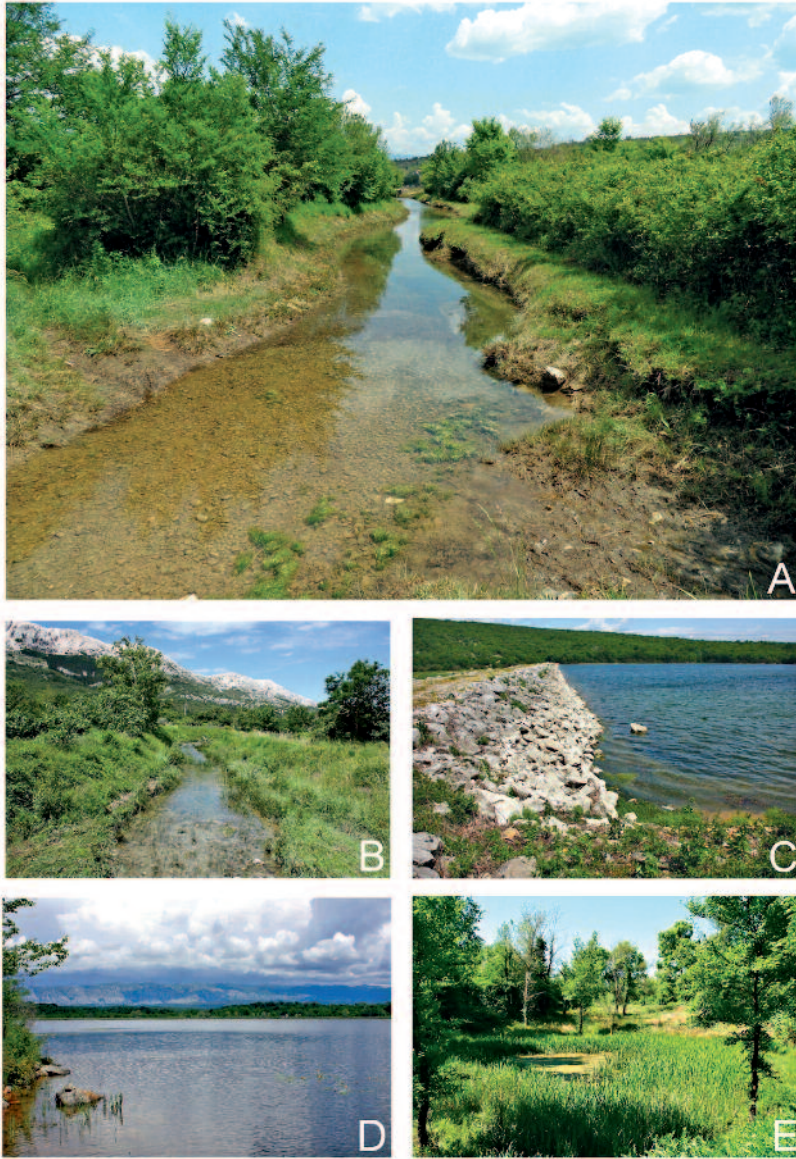


Fig. 2: Habitats of *Natrix tessellata* (LAURENTI, 1768) at current and historical finding locations on the Island of Krk. A - Part of the Veli potok stream, where the new record of *N. tessellata* comes from (photographed on May 24, 2012; photo: M. KUDLÁČEK); B - Suho Ričina (photographed on June 3, 2013); C - Ponikve Dam (photographed on May 25, 2012); D - Jezero Dam (photographed on June 6, 2013); E - Marsh near Miholjice (photographed on May 18, 2007). Photos B–E: P. VLČEK.

matian coast (e.g., JELIĆ & LELO 2011), and thus hints at a regional origin. The newly found specimen is either (i) allochthonous,

i.e., directly introduced or a successor of specimens introduced in the past, or (ii) autochthonous, i.e., a natural immigrant or



Fig. 3: The specimen of *Natrix tessellata* (LAURENTI, 1768) from the Veli Potok watercourse on the Island of Krk, found on September 28, 2011. Photo: M. KUDLÁČEK.

member of a local indigenous population. Although deliberate release even of allochthonous reptiles on Krk that may include Dice Snakes, cannot be doubted (SCHWEIGER 2012), no visibly sustainable population of *N. tessellata* appears to have developed since, although successful introductions are known from elsewhere in Europe (e.g., MEBERT 2011b; OBST & STRASSER 2011; TROBISCH & GLÄSSER-TROBISCH 2011).

The potential for autochthony of *N. tessellata* on Krk Island is likely to exist, as this species exhibits remarkable migratory abilities, resulting in a dynamic and fast colonization of suitable habitats and subsequent rapid population growth (e.g., BENDEL 1997; BAHÁ EL DÍN 2011; MEBERT 2011b, 2011c; STRUGARIU et al. 2011; VELENSKÝ et al. 2011; MEBERT et al. 2013). In contrast, the rarity of reported *N. tessellata* seems to doubt the successful colonization of Krk Island through transmarine dispersal of individuals from the near mainland. Alternatively, landing on inferior habitat stretches on coastal Krk may decrease survival of newly arrived, exhausted snakes; most would die after one season, either through

malnutrition or lack of proper hibernation sites. This could explain their apparent rarity on the island. Furthermore, frequent transmarine dispersal would require a healthy source population on the nearby mainland. Such are not known, and the coastal stretch on the mainland next to Krk Island provides little quality habitat for *N. tessellata* with no records to date (JELIĆ & LELO 2011).

However, with a closer look at the vis-à-vis coast using satellite and Panoramio images (GoogleEarth), the authors perceived a few small mainland water courses, where still undetected *N. tessellata* may exist in low numbers. For example, the town Crikvenica provides potential habitats at the stream Dubračina and its upstream widening, Lake Tribaljsko. The mouth of the river lies only 2.5 km opposite of Krk Island and the Soline Bay, into which the stream Veli Potok drains (the new record site of the Dice Snake). A similar situation, albeit with larger distances to Krk Island, exists for the urban stream at Novi Vinodolski, discharging into the Adriatic ca. 9 km south of Crikvenica, and the Rječina River at the seaport of Rijeka, 23 km north of Crikvenica. Dice

Snakes are well known to have adapted to conditions of sea coasts and foraging in marine habitats (e.g., GRUSCHWITZ et al. 1999; VAN DER MEIJDEN & CHIARI 2006; NAUMOV et al. 2011; STRUGARIU et al. 2011; TUNIYEV et al. 2011). Regarding the Adriatic Sea, coastal/marine Dice Snakes have been documented from the Italian coast, from Duino to the Delta of the Po River south of Venezia (BONATO et al. 2007; MEBERT 2011c), the Sečovlje salt pans, Adriatic coast of Slovenia, (KROFEL et al. 2009; ZAGAR et al. 2011), and in Croatia, from Ston and the deltas of the Zrmanja and Krka rivers (JELIĆ & LELO 2011; JELIĆ & LAUŠ 2011).

Due to the remarkable saline tolerance by *N. tessellata*, Dice Snakes from the Raša River (records in JELIĆ & LELO 2011) on the southern coast of the Istria Peninsula could swim/drift 15 to 25 km across the sea to reach Cres Island, that in fact holds a population (BURIĆ & BAŠKIERA in press), which is nearest to Krk Island. Water discharging from the mouth of the Raša River flows toward Cres Island and could easily lead swimming/floating Dice Snakes to Cres Island. From there, in the sense of a stepping stone, transmarine dispersal of Dice Snakes to Krk would require only a short, 3 to 5 km distance to swim. Such distances may well be crossed by Dice Snakes, as islands and even oil rigs and platforms between 5 km to 10 km from the nearest firm land are colonized by this species in the Caspian Sea (TUNIYEV et al. 2011). In the study region, even larger distances of up to 65 km were covered by another semi-aquatic reptile species, the European Pond Turtle, *Emys orbicularis* (LINNAEUS, 1758), as suggested by JELIĆ et al. (2012). These authors report that 14 of 21 turtles were still alive when they were detected on the island of Korčula in December 2010, either walking around or still entangled in floating sedge. They probably arrived there by having floated on driftwood from the Neretva estuary across seawater, around Janjina Peninsula to the shores of Korčula Island (JELIĆ et al. 2012).

The question arises if there is suitable habitat for *N. tessellata* on Krk Island. According to the authors' experience, this island is, among all Kvarner islands, the most suitable for colonization and perma-

nent occurrence of this species; the distance to the mainland is small and the environment on the island is adequately varied with many types of aquatic habitats. It has appropriate coastal habitats, including rocky shoreline and calm areas for foraging, similar as can be found in many other coastal marine populations of Dice Snakes (see references in MEBERT 2011a). Inland, the species could exist in any irrigation channel, like the current find from Veli Potok, and stream that provide structures for shelter and fish to prey on. Open freshwater habitats like ponds or lakes farther inland (e.g., Ponikve Dam, Jezero Dam, and the marsh near Miholjice) appear to offer suitable habitat requisites for *N. tessellata* (see Fig. 2). The freshwater systems on Krk are densely populated by *N. natrix*, which does however not preclude sympatry with *N. tessellata*. Co-existence between these *Natrix* species is a common phenomenon, as niche segregation based on microhabitat and food is distinct (e.g., JANEV HUTINEC & MEBERT 2011; IOANNIDIS & MEBERT 2011). Only limited resources could lead to interspecific competition (METZGER et al. 2009), but this does not apply to Krk Island.

Considering the previous reports of *N. tessellata* on Krk Island and the new specimens from the Veli Potok channel, the availability of suitable habitat on the island and its vicinity, and the verified findings from neighboring islands (Cres and Prvić), the authors suggest to classify *N. tessellata* as an autochthonous faunal element of Krk. Low population size and potential of nocturnal behavior on a dry, windy island (e.g., MEBERT et al. 2011; more references in MEBERT 2011a) may contribute to low detection probability. The authors expect future searches in the aquatic habitat near the Soline Gulf and across the island to reveal a population of *N. tessellata* on Krk Island.

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