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Spatio-temporal Bias in the Perceived Distribution of the European Pond Turtle, *Emys orbicularis* (Linnaeus, 1758), in Romania

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Abstract: The present study comprises an updated distribution of *Emys orbicularis* in Romania that emphasizes the spatio-temporal sampling. We have compiled a distribution database consisting of 866 *E. orbicularis* occurrence records in Romania, based on published data (76.4%), museum collections (2.8%) and personal field data (20.8%). *Emys orbicularis* holds an occupancy area of only 6% of Romania's territory aggregated in 603 5×5 km UTM cells. Out of these cells, 74% have only one record and 26% have two or more records. The altitudinal range is between 0–903 m a.s.l. There are temporal inconsistencies in terms of sampling effort with 50% of the data recorded from 1926 to 1996, and 50% recorded after 1996. We analyzed the spatial bias in the species distribution patterns using the Getis-Ord Gi* statistic on the number of records per UTM cell. The results revealed over-sampled (e.g., protected areas from Dobrogea Region) and possibly under-sampled regions (e.g., Danube floodplain) suggesting that the present distribution data are not reflecting the real distribution range. Understanding these distribution patterns has useful implications in future conservation policies and spatial planning.

Key words: Reptilia, inventory bias, hot spot analysis, distribution, conservation

Introduction

Accurate species distribution maps represent a key element in achieving the new Aichi Biodiversity Targets for 2020 (Venter et al. 2014). Although distribution maps are increasingly available from a variety of sources, both historical and current, they likely include biases towards certain time periods and areas. These biases need to be addressed in the way of obtaining a more accurate overview of species diversity (Boakes et al. 2010). It is estimated that 20% of reptiles worldwide are threatened and require urgent actions to improve their conservation status (Böhm et al. 2013). European conservation strategies rely on comprehensive datasets of sometimes unknown quality, as they differ within and among countries, with sampling effort skewed by factors such as accessibility and attractiveness of the sampling regions and (or) habitats (Romo et al. 2006).

The European Pond Turtle, *Emys orbicularis* (Linnaeus, 1758), has a wide-range distribution beyond the Europe's geographical limits (Arnold & Ovenden 2003). It extends from African Maghreb to the Baltic Sea and from Portugal to the Caspian Sea (Sillero et al. 2014). The species is considered Near Threatened according to IUCN regional Red Listing guidelines (van Dijk & Sindaco 2004, Cox & Temple 2009). This conservation status has been induced by habitat alteration, the introduction of predators and competitors (e.g., Raccoon, Raccoon Dog, Red-eared Slider Turtle), pollution and diseases (Cox & Temple 2009, Fritz & Chiari 2013).

The distribution of *E. orbicularis* in Romania was first compiled by Fuhn & Vancea (1961), followed by Sos (2011) and Cogălniceanu et al. (2013). Despite the increasing number of occurrence records, rising from 67 distribution records in 1961, 251 in 2011 and 753 in 2013, the sampling effort seemed biased in both time and space. Based on an updated distribution database of the European Pond Turtle in Romania, we estimated the sampling bias in time and space, aiming to provide a measure of inventory completeness.

Materials and Methods

We compiled a database in Microsoft Access software consisting of the distribution records of *E. orbicularis* in Romania from 1926 until 2014. The data were extracted from three major sources based on published data, museum collections, and personal field data. After the data quality was checked, we imported them in a GIS environment as geodatabase (see Cogălniceanu et al. 2013 for further details). For spatial representation we aggregated the distribution records to the Universal Transverse Mercator (UTM) grid system at a spatial resolution of 25 km^2 (5×5 km).

Spatial bias was assessed with Getis-Ord Gi* statistic, applied on the number of records aggregated to UTM 5×5 km cells. We aimed to identify the clusters of 5×5 km UTM cells where the sampling effort was significantly higher (hot spots) or lower (cold spots) than expected by chance. Temporal bias was assessed by plotting the accumulation of distribution records in time.

We plotted the observed altitudinal distribution of *E. orbicularis* as described by the 5×5 UTM cells with species reported present, alongside with the available altitudinal distribution as described by all 5×5 UTM cells within the species altitudinal range in Romania. We interpreted the differences in the two distributions as potential biases in the inventory effort at certain altitudes.

We performed all spatial analyses in ArcGIS Desktop 10.1 (ESRI, CA).

Results

We extracted and georeferenced 866 *E. orbicularis* occurrence records from published data (76.4%), museum collections (2.8%) and personal field data (20.8%) (Fig. 1). We added 113 new records in 2014, in addition to the 753 in Cogălniceanu et al. (2013). The records accumulation over time is presented in Fig. 2, with 50% of the records dated between 1926 and 1996 (a time-span of 70 years) and 50% after 1996 (18 years).

The occupancy area of *E. orbicularis* was 6% of Romania's territory aggregated in 603 5×5 km UTM cells (Fig. 3). Through the cells, 74% had only one occurrence record and 26% had two or more records. The Getis Ord Gi* revealed the hotspots of sampling effort (i.e., regions with sampling effort higher than expected by chance, Fig. 4).

The observed altitudinal distribution of *E. orbicularis* ranged from 0 to 903 m a.s.l. and had a bimodal response. The comparison with the available altitudinal distribution in that range emphasized

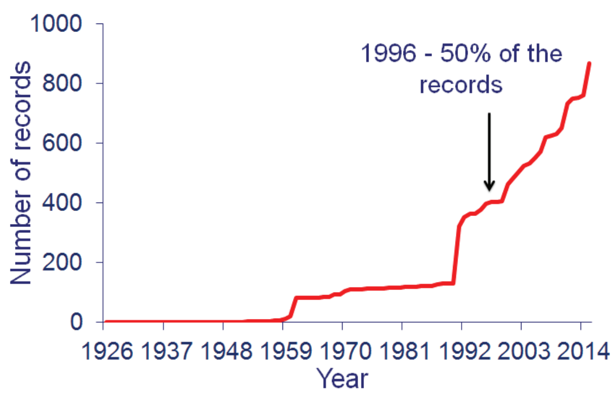

Fig. 2. The increase over time of distribution records for the European Pond Turtle (*Emys orbicularis*) in Romania (1926–2014)

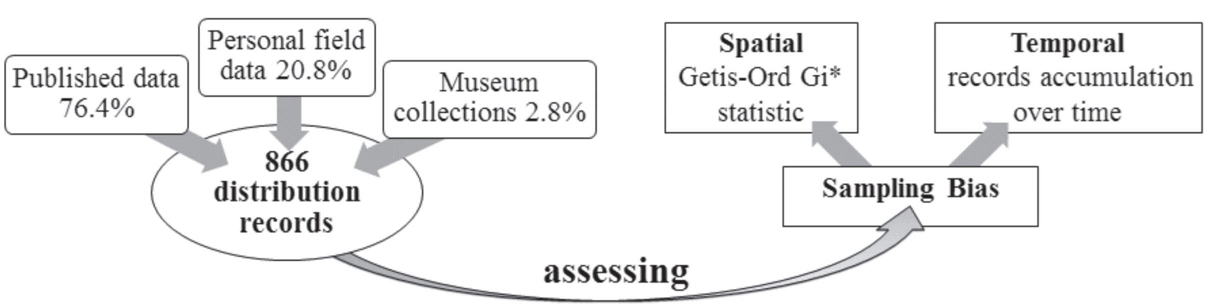

Fig. 1. The methods used for compiling and assessing records for spatio-temporal bias in the European Pond Turtle (*Emys orbicularis*) distribution in Romania (1926–2014)

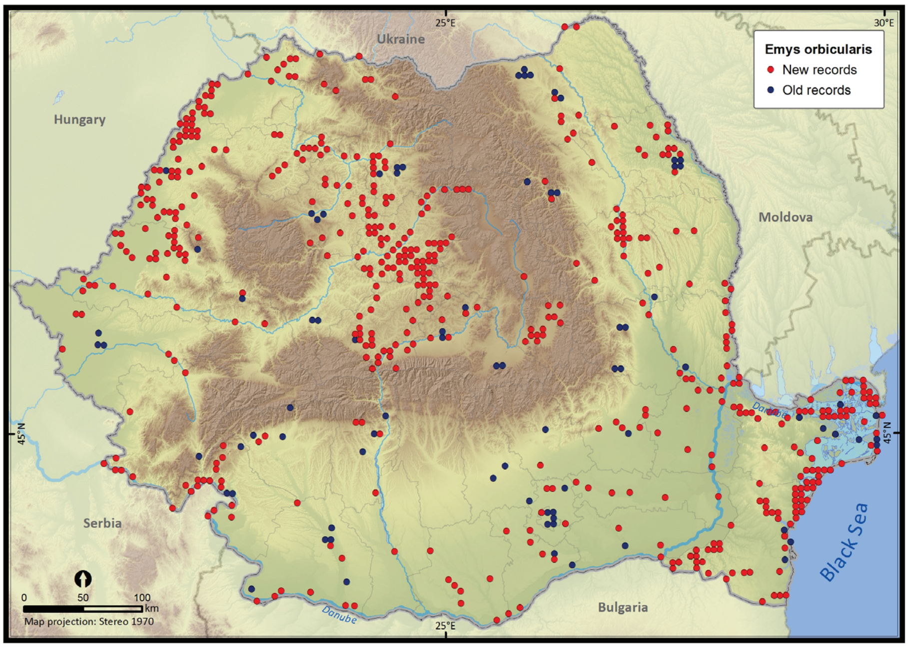

Fig. 3. Updated distribution of the European Pond Turtle (*Emys orbicularis*) in Romania based on 5×5 km UTM grid cells. Blue circles - old occurrences recorded between 1926 and 1996, and red circles - records between 1997 and 2014

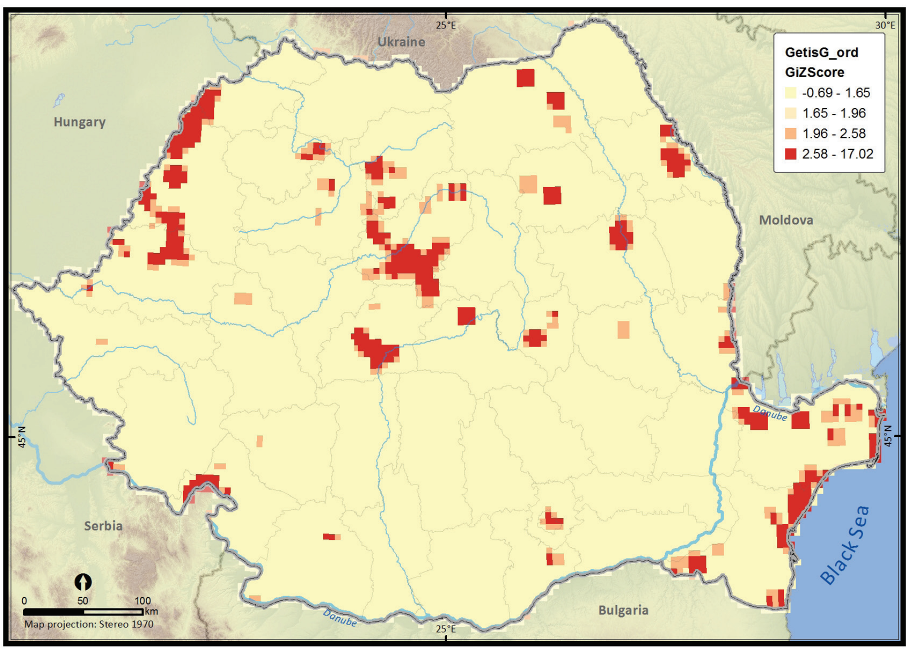

Fig. 4. Hot spots of sampling effort for the European Pond Turtle (*Emys orbicularis*) within Romania. Getis Org Gi* statistic on number of records per 5×5 km UTM cells

a knowledge gap of the distribution around 300 m a.s.l. (Fig. 5).

Discussion

We present an updated distribution of *E. orbicularis* in Romania and highlighted spatio-temporal bias of the dataset. The compiled data came from different sources with different collecting designs (Fig. 1). For this reason, strong spatio-temporal biases might appear (Botts et al. 2011). In order to identify these biases, we addressed a series of issues related to the quality and relevance of *E. orbicularis* distribution patterns in Romania. Our timeline number of publications points out that there are temporal inconsistencies in terms of sampling effort, with half of the distribution data in the last 18 years from a total of 88 years taken into account (Fig. 2). There was

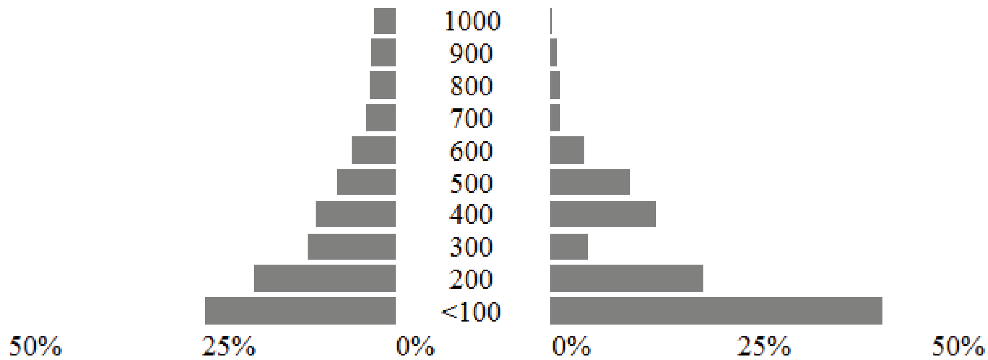

Fig. 5. The available (left) and the observed (right) altitudinal distribution of the European Pond Turtle (*Emys orbicularis*) in Romania

a slow accumulation of data from 1926 until 1989 and over the following years there was a substantial increase in the inventory effort. There are two thresholds identified on the timeline frame. The first threshold was in 1961, when the milestone book on Romanian reptiles was published (Fuhn & Vancea 1961) and the second one after 1989, showing a major increase in the inventory data.

The Getis Ord Gi* analysis revealed intensely sampled regions (hot spots) that correspond mostly to protected areas (e.g., the Danube Delta Biosphere Reserve, Măcin Mountains National Park, Iron Gates Natural Park, etc.). Neglected regions in terms of sampling records (cold spots) were not statistically significant (Fig. 4). This result was probably determined by the fine resolution used (25 km^2). We suspect that the neglected regions in terms of sampling effort are larger than the selected resolution. Cogălniceanu et al. (2013) found that inventory effort of reptile distribution in Romania is low in the entire agricultural region of southern Romania.

Another issue identified here is the difference between the observed altitudinal distribution of *E. orbicularis* (as described by our occurrence records) and the expected altitudinal distribution (as described by species altitudinal preferences). The observed altitudinal distribution of *E. orbicularis* is bimodal suggesting an under-estimated inventory of the areas ranging around 300 m a.s.l. (Fig. 5), with a peak in lowland areas (0 to 100 m a.s.l.) and another around 400 m a.s.l.

Our results suggest that the present distribution pattern does not reflect the *E. orbicularis* real range, being rather a picture of the inventory bias. Identifying and characterizing this spatial-temporal bias is helpful in directing further studies towards the under-sampled areas and, by describing the limits in data quality, in promoting consistent conservation policies and spatial planning (Ferraro & Pattanayak 2006).

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