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The Alien Pond Slider *Trachemys scripta* (Thunberg in Schoepff, 1792) in Bulgaria: Future Prospects for an Established and Reproducing Invasive Species

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Abstract: Since its appearance in pet stores in Bulgaria in the 1990s, the pond slider *Trachemys scripta* has been released at multiple localities across the country, but this process has been subject to limited scientific attention. Here, we update the distribution of this invasive alien species by adding 17 new squares to the previously published 30 of the 10×10 UTM grid. All three subspecies are present in the country, including a subadult *T. s. troostii* observed in 2018 at a single locality in Rupite Area, southwestern Bulgaria. More importantly, we report observations of hatchlings of *T. s. elegans* from two consecutive years in Rupite Area and of two subadults at Velyov Vir (Ropotamo River, Black Sea coast), strongly suggesting successful breeding in the wild. Furthermore, we provide the first national ecological niche model for *T. scripta*, concluding that large potentially suitable areas exist throughout the country, especially at low altitudes. We discuss similarities in the climatic conditions between the native range and Bulgaria, further suggesting that the species could likely survive and potentially reproduce across the country.

Key words: Introduced species, geographical range, red-eared slider, yellow-bellied slider, Cumberland slider.

Introduction

The pond slider turtle *Trachemys scripta* (Thunberg in Schoepff, 1792) is native across the central and eastern parts of North America, extending north almost up to the region of the Great Lakes (Lake Michigan) (VAN DIJK et al. 2014). This aquatic taxon comprises three subspecies: the red-eared

slider *T. s. elegans* (Wied-Neuwied, 1839), yellow-bellied slider *T. s. scripta* (Schoepff, 1792), and Cumberland slider *T. s. troostii* (Holbrook, 1836). *Trachemys s. elegans* has been introduced by humans to almost every continent (BRINGSØE 2006) and is evaluated to be among the 100 worst world's invaders (LOWE et al. 2000).

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In Europe, potential breeding in the wild of *T. s. elegans* has been reported from multiple countries, especially in the Mediterranean region: Portugal, Spain, France, Italy, Slovenia, Croatia, and Greece (GENIEZ & CHEYLAN 1987, FICETOLA et al. 2003, BRUEKERS et al. 2006, PEREZ-SANTIGOSA et al. 2008, GIRONDOT et al. 2012, VAMBERGER et al. 2012, SCHWEIGER 2015), but also in Austria (KLEWEIN 2014) and Serbia (Đorđević & ANĐELKOVIĆ 2015). The species is becoming increasingly abundant, especially in Portugal, Spain and France (VAN DIJK et al. 2014), with a clear tendency for expansion to the northern and eastern parts of Europe, evidenced by surviving populations in Poland, Germany, and Latvia (NAJBAR 2001, PIEH & LAUFER 2006, PUPINS 2007).

The invasive potential of the species has prompted legal measures to be taken. In 1997 the European Council banned the import of *T. s. elegans* into the European Union (EU) (EC 1997). This, however, quickly led to the mass importation of the nominate subspecies *T. s. scripta*, which has very similar ecological preferences and could potentially be just as invasive. By 2014, both *T. s. scripta* and *T. s. elegans* were banned for import in the EU (EU 2013, 2014a). Currently, the three subspecies are listed under the Regulation (EU) 1143/2014 on the invasive alien species (EU 2014b).

In Bulgaria, *T. scripta* is the only known alien herpetofaunal species. *Trachemys s. elegans* became a popular pet in the 1990s, resulting in mass intentional and accidental releases into the wild (although no quantitative data on releases exist), with sightings in urban and natural environments increasing after 1996 (TZANKOV et al. 2015). Although Bulgaria joined the EU in 2007, this species remained readily available as a pet (either through illegal imports or from breeders within the EU, but likely outside of Bulgaria). The first brief review of *T. scripta* sightings has been made by STOJANOV et al. (2011), followed by mappings by TZANKOV et al. (2015) and KUZMANOVA et al. (2018). Still, published data on the species distribution and the ecological impact in Bulgaria remain scarce and likely greatly underestimate the real situation. Due to the limited number of publications so far and the somewhat slow update of large-scale data collation projects, the species is yet to be officially listed for Bulgaria in reputable sources such as UETZ & HALLERMANN (2019) and the GLOBAL INVASIVE SPECIES DATABASE (2020).

Furthermore, the environmental characteristics of the country likely favour the potential for

widespread distribution of the species. On a relatively small area (~111,000 km²), Bulgaria exhibits highly diverse relief, ranging from extensive plains and lowlands to (sub-) alpine areas. Still, roughly 87.7% of the country is lower than 1,000 m in elevation, comprising lowlands: 0–200 m a.s.l. (31.4% of the territory), hills: 200–600 m a.s.l. (41%), and low mountains: 600–1,000 m a.s.l. (15.3%) (SIMEONOV & TOTZEV 1997). Although only ca. 0.3% of the Bulgarian territory is fresh water, wetlands of various sizes occupy over 100,000 ha, with a large portion being artificial and/or in close proximity to human settlements (MICHEV & STOYNEVA 2007), being easily accessible for releases of pet turtles by people. The climate throughout also seems suitable, ranging from temperate/humid continental in the central and northern parts of the country, to warm semi-Mediterranean climate in the southern parts.

Thus, given the biology and plasticity of the species, its lasting popularity in the pet trade, and the geographical variability within Bulgaria, it seems logical that high potential exists for *T. scripta* to become established and expand its range, at least locally. Therefore, this study: 1) updates the distribution of *T. scripta* in Bulgaria, 2) presents evidence for possible successful breeding of *T. s. elegans* in the wild, and 3) provides an initial estimate of the areas in the country which might be suitable for the long-term survival of released individuals and the possible establishment of local populations that could impact native biota.

Materials and Methods

Data collection and mapping

We compiled a dataset of previously unpublished sightings of *T. scripta* with exact coordinates, predominantly from 2015–2019, with seven observations from 2003–2014. We supplemented author's data with field observations by biologists and citizen scientists in the SmartBirds database (<https://smartbirds.org/>). We verified all records from SmartBirds prior to including them in the dataset by contacting the authors of the submissions in case of any discrepancies and by considering the available photographic evidence. Authors' field data were collected during surveys for the native freshwater turtles *Emys orbicularis* (Linnaeus, 1758) and *Mauremys rivulata* (Valenciennes in Bory de Saint-Vincent, 1833) and other freshwater herpetofauna, as well as during incidental observations. Surveys were performed throughout the country on various natural, semi-natural, and artificial water bodies and the surrounding terrain, representing

potentially suitable habitats for freshwater turtles. We supplemented these observations with the data published in TZANKOV et al. (2015) and KUZMANOVA et al. (2018), and references therein.

The dataset was plotted on the national 10×10 km Universal Transverse Mercator (UTM) grid (projection coordinate system ‘WGS 84 UTM 35N’, using the cell codes of the Military Grid Reference System, MGRS, spatially identical with UTM). We visualised the occurrences with software ArcGIS 10.3.1 (ESRI, Redlands, CA, USA).

Proximity to human settlements

We calculated proximity of observations to human settlements (including single buildings) in ArcGIS, using the 10-m resolution European Settlement Map residential/non-residential layer (level 2), based on imagery from 2014 to 2016 (SABO et al. 2019).

Elevation

To assess the known vertical distribution, to each previously unpublished observation with an exact coordinate we assigned an elevation, based on a Digital Elevation Model (40-m cell resolution). To decrease observer bias, we subsampled the observations, randomly leaving only one observation per 1×1 km cell from the UTM grid.

Ecological niche model

To evaluate the natural and semi-natural habitats (outside urban territories) potentially suitable for *T. scripta*, we used an Environmental Niche Model (ENM) created previously for *E. orbicularis* (KORNILEV et al. 2017). We chose this ENM because 1) *T. scripta* directly competes with *E. orbicularis* (and *M. rivulata*), with whom it shares multiple ecological and biological requirements; 2) *M. rivulata* has a much smaller known range and narrower ENM, limited to the southeastern and southwestern Bulgaria, almost completely overlapped by those for *E. orbicularis* (KORNILEV et al. 2017). However, from the original ENM for *E. orbicularis* we removed the territories at elevations above the highest recorded observation of *T. scripta* plus a buffer of ~50 m (extracted by mask, below 1,000 m of elevation).

Results

Distribution and mapping

We collected a total of 106 previously unpublished records for 241 individuals of *T. scripta*. Mostly, only one (71 records) or two individuals (13

records) were observed; three to nine turtles were seen in 18 records; 10 or more turtles were registered in four records. The localities with high densities of *T. scripta* included Nikolovo (9 individuals recorded on two occasions) (Fig. 1: MJ25) and an artificial lake in the Business Park, Sofia (10 individuals) (Fig. 1: FN92). Rupite Area (FL89) seems to harbour the highest densities: 10 individuals were observed twice; the record density was 8 *T. s. scripta* and 24 *T. s. elegans* during a visit to a marsh in May 2018.

A review of the available literature on the distribution of *T. scripta* in Bulgaria revealed published records for 30 UTM squares: 19 in TZANKOV et al. (2015) and 11 additional ones in KUZMANOVA et al. (2018). The new data fell in 26 UTM squares: 17 squares where the species was registered for the first time and 9 squares with previously published presence (Fig. 1; Appendix 1). By far the most records were made in square FL89 (42 records; Rupite Area, southwestern Bulgaria), followed by NH30 (11 records; Burgas region, near the Black Sea coast). Single records were registered in 13 squares; the remaining 11 UTM squares averaged 3.6 records per square (range: 2–7).

Overall, 44 individuals were unequivocally identified as *T. s. elegans*, and 179 – just as *T. scripta*. Only 23 individuals were identified as *T. s. scripta*; 22 of these were found in the Rupite Area (FL89). Of interest is a single observation by AP of a subadult of *T. s. troostii* in May 2018 in the Rupite Area (along the record number of *T. s. elegans* and *T. s. scripta*); so far, this is the first report of this subspecies for Bulgaria.

Trachemys scripta was found from the sea level up to 956 m (n=35). More than 68% of the observations were below 250 m a.s.l., while only three were above 600 m (Fig. 2). The highest record was in a marsh (ca. 0.5 ha in size), situated about 1.5 km southeast of Obel Village in Vlahina Mountain, close to the border with the Republic of North Macedonia.

Ecology and reproduction

Trachemys scripta was found in a range of artificial and natural aquatic habitats: canals, small lakes (up to 30 m²), lakes, marshes, small and bigger reservoirs, as well as streams and rivers. Of 69 localities (based on unique coordinates), 75.4% were less than 100 m away of human settlements (including single buildings), 95.6% were less than 200 m away, and the remaining three localities were 400–500 m away.

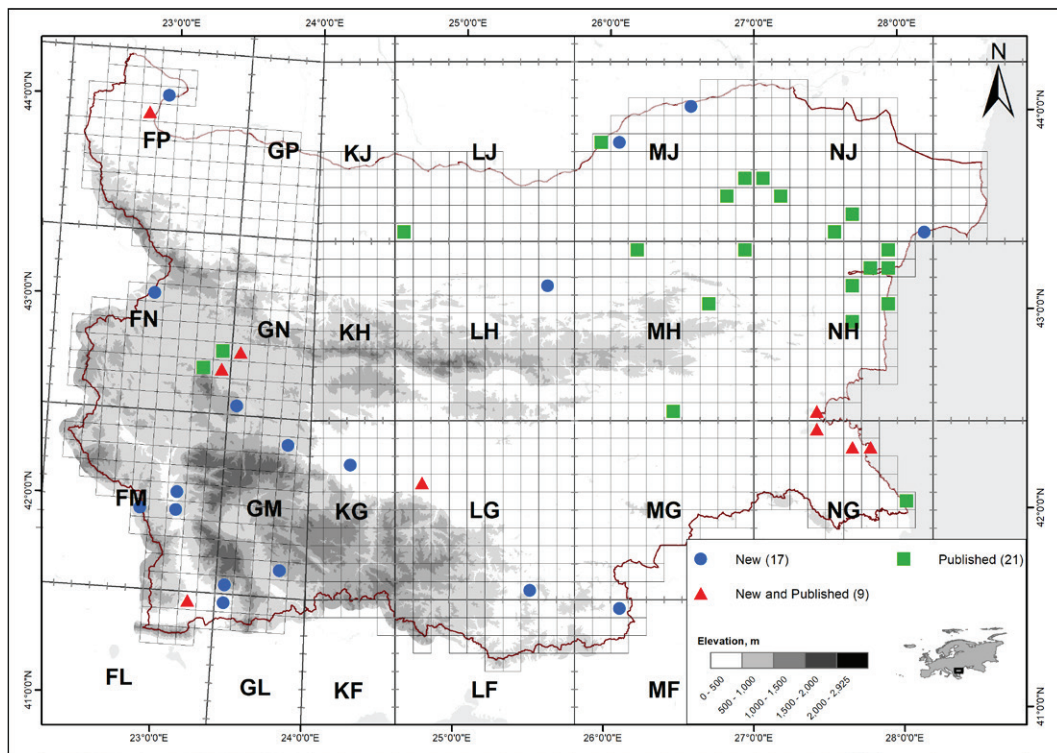


Fig. 1. Distribution of *Trachemys scripta* in Bulgaria, based on a 10-km UTM grid. Blue circles indicate UTM squares with new records; red triangles – UTM squares with new and published records; and green squares – UTM squares with published records.

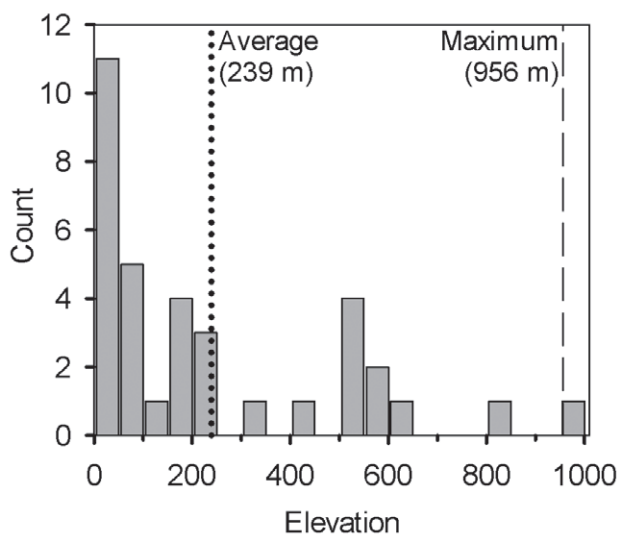


Fig. 2. Vertical distribution of exact localities of *Trachemys scripta* in Bulgaria based on 50-m altitudinal belts (n=35).

Out of 176 individuals with recorded age/size classes, 164 were adults (16 ♀, 9 ♂), nine – subadults, and three were juveniles. One of the juveniles was a recently hatched individual, captured in May 2018 by SL in a small pond near the canal at Rupite Area (88 m a.s.l.) (Fig. 3). The first reports of *T. scripta* hatchlings in the wild in Bulgaria were from the same locality

of Rupite and consist of two observations of three different newly-hatched individuals of *T. s. elegans* in the summer of 2017 (TZANKOV et al. 2017). By comparing photographs of the four hatchlings, we found that the individual from 2018 was different in colouration and smaller in size than the three turtles from 2017. Additional data on reproductive behaviour from the same locality include an observation by SL of a female *T. s. elegans* on land returning to the water after potential nesting in May 2018; in regards to *T. s. scripta*, MS noted two males courting females in May 2019. Therefore, these observations strongly suggest that *T. s. elegans* (possibly the nominate subspecies as well) could reproduce in the wild in southwestern Bulgaria (Rupite Area).

Ecological niche model

Based on the modified ENM for *E. orbicularis*, potentially suitable habitats for *T. scripta* exist throughout the country (Fig. 4). The ENM predicted that the potentially suitable area is from 5,544 km² to 12,946 km² (based on the original model's Medium + High suitability categories, and all suitable space, respectively). A visual comparison of our observations to the ENM suggests that the model could be applied successfully to predict the potential future range of *T. scripta* in Bulgaria.



Fig. 3. A hatchling *Trachemys scripta elegans*, Rupite Area, southwestern Bulgaria, 2018. The coin is 2.5 cm in diameter.

Discussion

We hypothesise that the increase in recorded observations and localities since the last publications does not necessarily correlate with an actual increase in the number of released individuals. The accumulation of data after 2015 is likely due to increased sampling efforts, and, more importantly, to the centralised database SmartBirds, which allows for easier compilation of observations. Still, historical rates of release of individuals in the wild will likely remain undetermined.

Distribution and mapping

We presume that the majority of individuals that were not recorded at the subspecies level would have been *T. s. elegans*. Because *T. s. elegans* has been the most prevalent subspecies in the pet trade, people tend to equate it to the species in general and do not record the subspecies identifier.

Our observations of *T. scripta* overlap almost completely with the vertical distribution of the two native species. 74.3% of the unbiased observations of *T. scripta* were in lowlands and hills, at altitudes lower than 500 m. For *E. orbicularis* 84.4% (n=1,310) of the records are at altitudes below 250 m, while 97.5% (n=1,513) are below 600 m; for *M.*

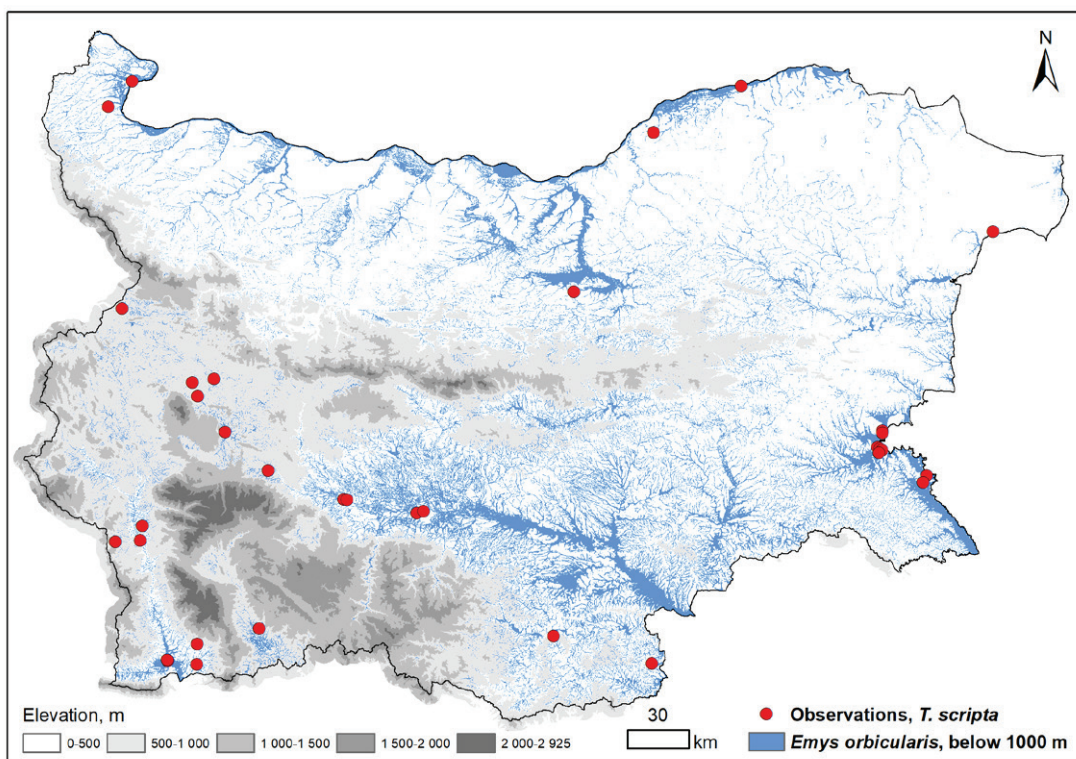


Fig. 4. Potential territory suitability for *Trachemys scripta* (blue areas) based on the ecological niche model for *Emys orbicularis* in KORNILEV et al. (2017). Red circles denote the localities of previously unpublished observations of *T. scripta*.

rivulata 93.1% (n=108) of the records are below 250 m (KORNILEV et al. 2017).

Ecology and reproduction

Diverse aquatic habitats, similar to those observed in this study, have been reported in TZANKOV et al. (2015). Still, the habitats in which *T. scripta* were recorded during this study are likely more indicative of the type of sites where people normally release their pet turtles, or of the type of habitats in which the individuals can successfully overwinter, rather than the species' real habitat preference. Although the species prefers mostly stagnant waters, it is highly adaptable and has been recorded in a wide-variety of natural and artificial, stagnant and flowing freshwater habitats, but also in brackish ones (SOMMA et al. 2019, UETZ & HALLERMANN 2019).

Predictably, almost all observations of *T. scripta* were made in a very close proximity to human buildings, often at a distance of <100 m. Out of the records 400–500 m away from human constructions, two were from Velyov Vir (Vodnite Lili) Managed Nature Reserve, near the Ropotamo River; although the distance refers to a single building, the town of Primorsko is about 3.5 km away. The record furthest from a human settlement (495 m) was from the Studen Kladenets Reservoir, which is surrounded by buildings, including those of the town of Kardzhali about 11 km away. All of our results support the notion that at the moment the distribution of *T. scripta* in Bulgaria is highly correlated with the proximity to human settlements, as a result of intentional releases.

TZANKOV et al. (2015) reported that sliders have been repeatedly observed to lay eggs in semi-natural conditions, but with no documented hatchings. Although the sex of relatively few individuals has been documented, the ratio of 1♂ : 1.78♀ suggests sufficient opportunities for egg fertilisation.

Besides the observation of likely naturally hatched individuals in the Rupite Area, speculative evidence for reproduction of *T. s. elegans* in Bulgaria is the observation of two small-sized individuals in Velyov Vir, in May 2017. The locality is relatively remote, compared to the ample more human-accessible aquatic habitats in the region. Although these subadults might be released pets, we hypothesise that they were the progeny of adults released on site and/or migrants from a more human-accessible point, e.g. the bridge over the Ropotamo River.

There are three major reasons that provide likely explanation for the multiple observations, including of hatchlings, in the area of Rupite. 1) Rupite and the surroundings are amongst the

most heavily visited areas in the country by both Bulgarian and foreign biologists and herpetologists due to its highly diverse and specific flora and fauna, resulting in multiple observations of adult turtles and has increased the chance to observe the otherwise difficult to spot turtle hatchlings. 2) The climatic conditions are highly suitable for the sliders. They are very specific, transitional between continental and Mediterranean, characterised by hot dry summers and mild winters. The thermal springs issuing in the area reach a temperature of 71–78°C and have an average discharge of 35 l/sec. Several small ponds (the largest with a surface area of about 0.02 ha) with varying temperatures (from over 60°C to 20°C) are formed near the springs and drain into a canal. Thus, chances for die-offs during cold winters (likely a frequent occurrence in northern Bulgaria) are minimal. Furthermore, the area is highly suitable for both native turtle species, based on multiple observations and on ecological niche models (KORNILEV et al. 2017). 3) Finally, the site is a very popular tourist attraction for citizens of Bulgaria, Greece and North Macedonia. This likely explains the high number of the observed *T. scripta* (*T. s. elegans* and *T. s. scripta*) in the small ponds. This increases the possibilities of coexistence of males and females that could lead to laying of fertile eggs and, subsequently, the chance for the presence of genes allowing successful hatching under these environmental conditions. Rupite Area represents a likely locality for the release and possible survival of other aquatic turtles, as indicated by several observations in April and May 2018 of an unidentified softshell turtle species (family Trionychidae; potentially *Trionyx triunguis*, sold in Bulgaria) that could not be captured (MS, Angel Dyugmegdzhev, pers. comm.).

Furthermore, we stress that it is possible that the species might also be reproducing in other localities (besides Rupite and Velyov Vir) with similar environmental conditions, especially in the south (see next sections), but without having been detected so far.

Ecological niche model

When interpreting the ENM for *T. scripta*, it should be noted that a large number of important potential habitats, namely, artificial water fountains, ponds, etc. in urban and peri-urban settings are missing from the digital layer with surficial waters used in the original modelling for *E. orbicularis*; although likely not significant in terms of their area, they are amongst the popular release sites for unwanted pets and in some cases, especially in peri-urban settings,

serve as reservoirs from which the sliders could disperse to habitats with native turtles.

While BRINGSØE (2001) suggested that the climate in Europe is not suitable for successful development of *T. scripta* eggs (cold winters in the north, hot dry summers in the south), by now the numerous reports of confirmed reproduction (KOREN et al. 2018) and the observations presented in our work provide evidence to the contrary.

Furthermore, possible breeding of the species in Bulgaria is supported by another climate model. Based on the present high-resolution Köppen-Geiger climate classification map version 2 (BECK et al. 2018), major climate classes occurring in the native range of *T. s. elegans* (SOMMA et al. 2019) are also present in areas of Bulgaria, at least parts of which were predicted by the ENM as suitable: 1) *Dfa* (Cold, no dry season, hot summer) – in the northern United States of America / in northern Bulgaria; 2) *BSk* (Arid, steppe, cold) – along the western native range / in the southwestern Bulgaria and along its Black Sea coast (although, the label is misleading as these territories are among the warmest in the country); 3) *Cfa* (Temperate, no dry season, hot summer) – southeastern USA / southeastern and central southern Bulgaria; the type locality of *T. s. elegans* also occurs within *Cfa* (SEIDEL & ERNST 2006; likely refers to the town of New Harmony, 38°07'03"N; 87°56'00"W). *Dfb* (Cold, no dry season, warm summer) mostly coincides with the high mountains of Bulgaria (Stara Planina, Rila, Pirin, Western Rhodopes), where the species has not been found and which are not suitable according to the model.

However, when predicting potentially suitable habitats for *T. scripta*, specific local conditions should be taken into account as they could greatly diminish its survival rate in the wild. Besides the recorded cases of die-offs due to cold weather (STOYANOV 2015, TZANKOV et al. 2015), other natural causes might decrease their populations. For example, it is hypothesised that the seasonal catastrophic flooding of the Veleka River may displace and potentially kill the sliders but not the native species (POPGEOGIEV et al. 2017).

On the other hand, *T. scripta* is highly plastic and adaptable. In a recent study ESPINDOLA et al. (2019) have predicted the niche changes for *T. scripta* based on the species tolerance limits and survival-associated factors. According to their results, the species occupies a wider range of temperatures along its non-native distribution (1.7–28.4°C), compared to its native range (5.3–23.7°C), making the non-native realised thermal niche greater than the native one. The authors have identified suitable environmental

conditions for potential slider invasion and have emphasised the need for distinction between areas, where the species can reproduce successfully, and those, where it can only survive. In this regard, for the purpose of accurate invasiveness assessments, it is especially important not only to map the slider distribution, but to establish such suitable areas on a regional scale. Our study has attempted to do so for Bulgaria. The detailed habitat information for the sites where hatchlings have been found could serve as the basis for future concentrated conservation efforts.

Implications for the native chelonians

Trachemys scripta have some advantages that potentially allow them to displace native chelonians: e.g. better thermoregulatory abilities (POLO-CAVIA et al. 2012), more competitive behaviour when feeding (POLO-CAVIA et al. 2010) and utilising basking sites (CADI & JOLY 1999, 2004). While at present there is no evidence that *T. scripta* in Bulgaria displace either *E. orbicularis* or *M. rivulata*, the fact that the number of new registered localities is constantly increasing, is of great concern. At the same time, with the expansion of knowledge, especially of targeted studies on the interactions between the native and alien species, this perceived balance could be in fact disturbed.

While the EU limits the introduction of new turtles into the pet trade, we urge for more stringent control over pet owners, including enforced registration, marking and follow-up control of the fate of individual *T. scripta*. This should allow to identify the owners of released turtles and to take the corresponding legal actions that should limit future releases. A mechanism to humanely remove the existing individuals from the wild should also be devised.

Conclusions

This study indicates that *T. scripta* has a wider distribution in Bulgaria than previously reported. The species also likely breeds successfully in certain localities in the wild. In addition, the ecological possibilities for future expansion of its range must be explored further, as there is mounting evidence based on climate and ecological niche models that large portions of the country could support adults and even successful reproduction, especially under the ongoing climate changes. Future studies need to establish more firmly the breeding potential of the *T. scripta* in Bulgaria, assess its impact, and propose conservation measures to be implemented.

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References

- BECK H. E., ZIMMERMANN N. E., MCVICAR T. R., VERGOPOLAN N., BERG A. & WOOD E. F. 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Nature Scientific Data* 5: 180214.
- BRINGSØE H. 2001. *Trachemys scripta* (Schoepff, 1792) – Buchstaben-Schmuckschildkröte. In: FRITZ U. (Ed.): *Handbuch der Reptilien und Amphibien Europas, Schildkröten (Testudines) I*. Wiebelsheim: Aula, pp. 525–583.
- BRINGSØE H. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Trachemys scripta*. Online Database of the North European and Baltic Network on Invasive Alien Species. <http://www.nobanis.org>.
- BRUEKERS J., UIJTERSCHOUT G. & BROUWER A. 2006. Erstnachweis einer natürlichen Vermehrung der Rotwangen-Schmuckschildkröte (*Trachemys scripta elegans*) auf der griechischen Insel Kos. *Schildkröten im Fokus* 3 (3): 29–34.
- CADI A. & JOLY P. 1999. The introduction of the Slider turtle (*Trachemys scripta elegans*) in Europe: competition for basking sites with the European Pond Turtle (*Emys orbicularis*). *Chelonii* 2: 95–100.
- CADI A. & JOLY P. 2004. Impact of the introduction of the Red-eared Slider (*Trachemys scripta elegans*) on survival rates of the European Pond Turtle (*Emys orbicularis*). *Biodiversity and Conservation* 13: 2511–2518.
- Dorđević S. & ANĐELKOVIĆ M. 2015. Possible reproduction of the Red-eared Slider, *Trachemys scripta elegans* (Reptilia: Testudines: Emydidae), in Serbia, under natural conditions. *Hyla* 1: 44–49.
- ESPINDOLA S., PARRA J. L. & VÁZQUEZ-DOMÍNGUEZ E. 2019. Fundamental niche unfilling and potential invasion risk of the Slider turtle *Trachemys scripta*. *PeerJ* 7: e7923.
- EC 1997. Council Regulation (EC) No 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by regulating trade therein. *OJL* 61, 3.3.1997. <http://data.europa.eu/eli/reg/1997/338/oj>
- EU 2013. Commission Implementing Regulation (EU) No 578/2013 of 17 June 2013 suspending the introduction into the Union of specimens of certain species of wild fauna and flora. *OJL* 169, 21.6.2013, p. 1–21. http://data.europa.eu/eli/reg_impl/2013/578/oj
- EU 2014a. Commission Implementing Regulation (EU) No 888/2014 of 14 August 2014 prohibiting the introduction into the Union of specimens of certain species of wild fauna and flora. *OJL* 243, 15.8.2014, p. 21–38. http://data.europa.eu/eli/reg_impl/2014/888/oj
- EU 2014b. Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species *OJL* 317, 4.11.2014, p. 35–55. <http://data.europa.eu/eli/reg/2014/1143/oj>
- FICETOLA G. F., MONTI A. & PADOA-SCHIOPPA E. 2003. First record of reproduction of *Trachemys scripta* in the Po Delta. *Museo Civico di Storia Naturale Ferrara* 5: 125–128.
- GENIEZ P. & CHEYLAN M. 1987. Atlas de distribution des Reptiles et Amphibiens du Languedoc-Roussillon. Montpellier: Laboratoire de Biogéographie et Ecologie des Vertébrés de l'EPHE / Groupe de Recherche et d'Information sur les Vertébrés, 115 p.
- GIRONDOT M., DELMAS V. & PRÉVOT-JULLIARD A-C. 2012. Nouvelles données sur la ponte de la tortue de Floride (*Trachemys scripta elegans*) en Île-de-France. *Bulletin de la Société Herpétologique de France*, Paris 142–143: 71–78.
- GLOBAL INVASIVE SPECIES DATABASE. 2020. Species profile: *Trachemys scripta elegans*. Available at: <http://www.iucngisd.org/gisd/speciesname/Trachemys+scripta+elegans>. [Accessed 20 May 2020].
- KLEWEIN A. 2014. Natural reproduction of *Trachemys scripta troostii* (Holbrook, 1836) x *Trachemys scripta scripta* (Schoepff, 1792) in Austria. *Herpetozoa* 26 (3/4): 183–185.
- KOREN T., ŠTIH A., BURIĆ I., KOLLER K., LAUŠ B. & ZADRAVEC M. 2018. The current distribution of Pond Slider *Trachemys scripta* in Croatia. *Natura Sloveniae* 20 (1): 33–44.
- KORNILEV Y. V., POPGEORGIEV G., NAUMOV B., STOYANOV A. & TZANKOV N. 2017. Updated distribution and ecological requirements of the native freshwater turtles in Bulgaria. *Acta Zoologica Bulgarica*, Supplement 10: 65–76.
- KUZMANOVA Y., NATCHEVA I., KOLEVA V., POPGEORGIEV G., SLAVCHEV M. & NATCHEV N. 2018. Public awareness of risks and recent marketing dynamics of Pond Sliders (*Trachemys scripta*, Schoepff, 1792) in NE Bulgaria. *Zoology and Ecology* 28 (4): 329–336.
- LOWE S., BROWNE M., BOUDJELAS S. & DE POORTER M. 2000. 100 of the World's Worst Invasive Alien Species: A selection from the Global Invasive Species Database. Auckland: The Invasive Species Specialist Group (ISSG), Species Survival Commission (SSC), World Conservation Union (IUCN), 12 p.
- MICHEV T. & STOYNEVA M. P. 2007. Inventory of Bulgarian wetlands and their biodiversity. Part 1: Non-lotic Wetlands. Sofia: Svetlostrouy Publ., 355 p.
- NAJBAR B. 2001. The Red-eared Terrapin *Trachemys scripta elegans* (Wied, 1839) in the Lubuskie province (western Poland). *Przegląd Zoologiczny* 45 (1–2): 103–109.
- PÉREZ-SANTIGOSA N., DÍAZ-PANIAGUA C. & HIDALGO-VILA J. 2008. The reproductive ecology of exotic *Trachemys scripta elegans* in an invaded area of southern Europe. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18: 1302–1310.
- PIEH A. & LAUFER H. 2006. Die Rotwangen-Schmuckschildkröte (*Trachemys scripta elegans*) in Baden-Württemberg – mit Hinweis auf eine Reproduktion im Freiland. *Zeitschrift für Feldherpetologie* 13 (2): 225–234.
- POLO-CAVIA N., LÓPEZ J. & MARTÍN P. 2010. Aggressive interactions during feeding between native and invasive freshwater turtles. *Biological Invasions* 13: 1387–1396.

- POLO-CAVIA N., LÓPEZ J. & MARTÍN P. 2012. Feeding status and basking requirements of freshwater turtles in an invasion context. *Physiology & Behavior* 105: 1208–1213.
- POPGEORGIEV G., KORNILEV Y. V., NATCHEV N., NAUMOV B., IVANCHEV I., SLAVCHEV M., STOYANOV A. & TZANKOV N. 2017. Spatial distribution of *Emys orbicularis* (L., 1758) and *Mauremys rivulata* (Valenciennes, 1833) in the lower Veleka River, Bulgaria: First observations. *Acta Zoologica Bulgarica*, Supplement 10: 129–132.
- PUPINS M. 2007. First report on recording of the invasive species *Trachemys scripta elegans*, a potential competitor of *Emys orbicularis* in Latvia. *Acta Universitatis Latviensis* 723: 37–46.
- SABO F., CORBANE C., PANAGIOTIS P. & KEMPER T. 2019. The European Settlement Map 2019 release: Application of the symbolic machine learning to Copernicus VHR imagery. Technical Report of the Joint Research Centre (European Commission). DOI: 10.2760/25824
- SCHWEIGER M. 2015. First record of breeding of the alien turtle species *Trachemys scripta elegans* in the wild on the island of Krk, Croatia? *Hyla* 1: 50–52.
- SEIDEL M. E. & ERNST C. H. 2006. *Trachemys scripta*. *Catalogue of American Amphibians and Reptiles* 831: 1–94.
- SIMEONOV Y. & TOTZEV M. 1997. Morphometrics. In: JORDANOVA M. & DONCHEV D. (Eds.): *Geography of Bulgaria. Physical Geography. Socio-economic Geography*. Sofia: 'Prof. Marin Drinov' Academic Publishing House, pp. 49–54. (In Bulgarian).
- SOMMA L. A., FOSTER A. & FULLER P. 2019. *Trachemys scripta elegans* (Wied-Neuwied, 1838): U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL. Revision Date: 7/30/2018. Available at: <https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1261>. [Accessed on 28 October 2019]
- STOJANOV A., TZANKOV N. & NAUMOV B. 2011. Die Amphibien und Reptilien Bulgariens. Frankfurt am Main: Chimaira, 588 p.
- STOYANOV A. 2015. Registered high mortality of allochthon Red-eared Sliders (*Trachemys scripta elegans*) in an artificial pool in Sofia, Bulgaria. *Hyla* 1: 65–69.
- TZANKOV N., POPGEORGIEV G., KORNILEV Y., NATCHEV N., STOYANOV A., NAUMOV B. & IVANCHEV I. 2015. First survey on the invasive Pond Slider (*Trachemys scripta*) in Bulgaria: Historic development and current situation. *Hyla* 1: 18–27.
- TZANKOV N., STOJANOV A., DOBREV D., LUKANOV S., KORNILEV Y., ANDONOV K., VERGILOV V. & POPGEORGIEV G. 2017. *Trachemys scripta* (Thunberg in Schoepff, 1792). In: TRICHKOVA T., VLADIMIROV V., TOMOV R. & TODOROV M. (Eds.): *Guide to Invasive Alien Species of European Union concern*. Sofia: IBER-BAS, ESENIAS, pp. 110–113. (In Bulgarian)
- UETZ P. & HALLERMANN J. 2019. The Reptile Database: *Trachemys scripta* (Thunberg in Schoepff, 1792). Available at: <http://reptile-database.reptarium.cz/species?genus=Trachemys&species=scripta>. [Accessed 28 October 2019].
- VAMBERGER M., LIPOVŠEK G. & GREGORIČ M. 2012. First reproduction record of *Trachemys scripta* (Schoepff, 1792), in Slovenia. *Herpetozoa* 25: 76–79.
- VAN DIJK P. P., IVERSON J. B., RHODIN A. G. J., SHAFFER H. B. & BOUR R. 2014. Turtles of the world, 7th edition: Annotated checklist of taxonomy, synonymy, distribution with maps, and conservation status. In: RHODIN A. G. J., PRITCHARD P. C. H., VAN DIJK P. P., SAUMURE R. A., BUHLMANN K. A., IVERSON J. B. & MITTERMEIER R. A. (Eds.): *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*. Chelonian Research Monographs 5 (7): 329–479.

Appendix 1. Supplementary data for the distribution records of *Trachemys scripta* in Bulgaria.

Previous publications: UTM/MGRS codes of 10-km cells

TZANKOV et al. (2015): FL89, FN82, FN92, FN93, FP46, GN03, LG16, LJ00, MH50, MH99, MJ15, NG39, NG58, NG68, NG85, NH30, NH55, NH76, NH78

KUZMANOVA et al. (2018): MH76, MH39, NJ12, NJ03, MJ82, NH79, NJ51, NJ40, MJ93, NH57, NH68

This study

Year	Month	Day	Latitude	Longitude	Species	UTM Code
2003	7	17	41.444444	23.438139	<i>Trachemys scripta</i>	GL09
2006	4	16	43.882861	22.756389	<i>Trachemys scripta</i>	FP46
2007	3	24	44.001667	22.892722	<i>Trachemys scripta</i>	FP57
2013	4	27	42.51978	27.4692	<i>Trachemys scripta</i>	NH30
2013	4	28	42.51978	27.4692	<i>Trachemys scripta</i>	NH30
2014	5	7	41.45858	23.26404	<i>Trachemys scripta</i>	FL89
2014	5	8	41.45858	23.26404	<i>Trachemys scripta</i>	FL89
2015	4	30	42.685218	23.342713	<i>Trachemys scripta</i>	FN92
2015	5	1	42.685218	23.342713	<i>Trachemys scripta</i>	FN92
2015	5	16	42.685325	23.342187	<i>Trachemys scripta</i>	FN92
2015	5	17	42.685325	23.342187	<i>Trachemys scripta</i>	FN92
2015	5	22	42.705	23.469	<i>Trachemys scripta</i>	GN03
2015	7	1	41.968056	22.925694	<i>Trachemys scripta</i>	FM54
2015	8	1	41.612972	23.794583	<i>Trachemys scripta</i>	GM31
2015	10	1	42.472778	23.549861	<i>Trachemys scripta</i>	GN00
2015	11	14	42.685237	23.342378	<i>Trachemys scripta</i>	FN92
2016	4	4	42.685237	23.342378	<i>Trachemys scripta</i>	FN92
2016	4	15	42.452849	27.453594	<i>Trachemys scripta</i>	NH30
2016	4	20	42.45299	27.454206	<i>Trachemys scripta</i>	NH30
2016	4	21	42.45299	27.454206	<i>Trachemys scripta</i>	NH30
2016	5	14	41.61526	25.5286	<i>Trachemys scripta elegans</i>	LG70
2016	6	5	42.043056	23.081111	<i>Trachemys scripta</i>	FM75
2016	6	6	44.052573	26.61728	<i>Trachemys scripta</i>	MJ67
2016	6	28	41.534193	23.434128	<i>Trachemys scripta</i>	GM00
2016	9	13	42.153199	24.74402	<i>Trachemys scripta</i>	LG16
2016	9	14	42.153199	24.74402	<i>Trachemys scripta</i>	LG16
2017	3	20	42.530886	27.469945	<i>Trachemys scripta</i>	NH30
2017	3	27	41.457117	23.264773	<i>Trachemys scripta</i>	FL89
2017	3	27	41.458167	23.262922	<i>Trachemys scripta</i>	FL89
2017	3	27	41.458412	23.26288	<i>Trachemys scripta</i>	FL89
2017	3	27	41.458415	23.262777	<i>Trachemys scripta</i>	FL89
2017	3	27	41.458863	23.26252	<i>Trachemys scripta</i>	FL89
2017	3	27	41.45835	23.26288	<i>Trachemys scripta</i>	FL89
2017	3	27	41.45835	23.26288	<i>Trachemys scripta scripta</i>	FL89
2017	4	3	41.456123	23.264987	<i>Trachemys scripta</i>	FL89
2017	4	4	41.979278	23.071611	<i>Trachemys scripta</i>	FM74
2017	4	15	41.453611	23.266778	<i>Trachemys scripta</i>	FL89
2017	5	4	42.299928	27.710615	<i>Trachemys scripta</i>	NG58
2017	5	4	42.300135	27.710352	<i>Trachemys scripta</i>	NG58
2017	5	4	42.300135	27.710352	<i>Trachemys scripta elegans</i>	NG58
2017	5	4	42.299928	27.710615	<i>Trachemys scripta elegans</i>	NG58

Year	Month	Day	Latitude	Longitude	Species	UTM Code
2017	5	7	41.458468	23.26278	<i>Trachemys scripta</i>	FL89
2017	5	7	41.458992	23.262592	<i>Trachemys scripta</i>	FL89
2017	7	6	42.144506	24.704372	<i>Trachemys scripta</i>	LG16
2017	7	15	42.444045	27.466979	<i>Trachemys scripta</i>	NG39
2017	8	6	41.458415	23.262805	<i>Trachemys scripta</i>	FL89
2017	8	6	41.458409	23.2628	<i>Trachemys scripta</i>	FL89
2017	8	6	41.458409	23.2628	<i>Trachemys scripta scripta</i>	FL89
2018	3	9	43.845078	26.085024	<i>Trachemys scripta</i>	MJ25
2018	3	9	43.844581	26.084368	<i>Trachemys scripta</i>	MJ25
2018	3	10	42.310556	23.8125	<i>Trachemys scripta</i>	GM38
2018	3	29	42.997597	22.900485	<i>Trachemys scripta</i>	FN56
2018	4	2	41.453463	23.26678	<i>Trachemys scripta</i>	FL89
2018	4	2	41.454441	23.265991	<i>Trachemys scripta</i>	FL89
2018	4	18	42.433475	27.447354	<i>Trachemys scripta</i>	NG39
2018	4	20	42.196341	24.267515	<i>Trachemys scripta</i>	KG77
2018	4	20	42.194245	24.286556	<i>Trachemys scripta</i>	KG77
2018	4	25	42.433475	27.447354	<i>Trachemys scripta</i>	NG39
2018	5	11	41.458354	23.26226	<i>Trachemys scripta elegans</i>	FL89
2018	5	11	41.458354	23.26226	<i>Trachemys scripta scripta</i>	FL89
2018	5	11	41.458354	23.26226	<i>Trachemys scripta troostii</i>	FL89
2018	5	23	41.454332	23.266414	<i>Trachemys scripta</i>	FL89
2018	5	23	41.457369	23.264052	<i>Trachemys scripta</i>	FL89
2018	5	29	43.404129	28.146455	<i>Trachemys scripta</i>	NJ90
2018	5	29	43.404129	28.146455	<i>Trachemys scripta elegans</i>	NJ90
2018	5	29	43.404129	28.146455	<i>Trachemys scripta scripta</i>	NJ90
2018	6	3	42.443987	27.465278	<i>Trachemys scripta</i>	NG39
2018	6	24	41.457682	23.263378	<i>Trachemys scripta</i>	FL89
2018	7	31	42.458883	27.440112	<i>Trachemys scripta</i>	NH30
2018	9	3	43.844581	26.084368	<i>Trachemys scripta</i>	MJ25
2018	9	3	43.845078	26.085024	<i>Trachemys scripta</i>	MJ25
2018	11	4	42.531009	27.470002	<i>Trachemys scripta</i>	NH30
2019	4	29	42.332261	27.732221	<i>Trachemys scripta elegans</i>	NG68
2019	5	3	41.458955	23.262551	<i>Trachemys scripta scripta</i>	FN92
2019	5	6	41.498538	26.106473	<i>Trachemys scripta</i>	MF29
2019	7	25	43.136451	25.613439	<i>Trachemys scripta</i>	LH87
2019	9	10	42.626091	23.376004	<i>Trachemys scripta elegans</i>	FN92

