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RESEARCH

Nesting ecology and confirmed breeding of the invasive pond slider *Trachemys scripta* in an urban environment, Romania

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Abstract

The pond slider (*Trachemys scripta*) is a major invasive species in freshwater habitats across the world. For decades, the main cause of individuals' occurrences in the wild was the illegal release of pet animals. Recently, as an important component of their management, there has been an increasing focus on their ability to successfully reproduce in the invaded regions. In Romania, the species is reported as widespread in urban wetland environments within major cities, but information about its nesting and potential breeding remains scarce or anecdotal. We surveyed a large population of pond sliders in an artificial urban wetland site in Constanţa, SE Romania, and described their nesting ecology and reproductive output. Although eggs from several nests failed to hatch or were predated, potentially limiting their reproductive success, sliders were found to breed successfully at this site, with 18.6% viable hatchlings recorded. Our study could serve as a baseline for additional targeted surveys and to inform decision-making for successfully managing this invasive species. Although the importation, trading, and breeding of this species are prohibited by EU legislation, active and effective management is now required to address the successful reproduction and further potential spread of *T. scripta*.

Keywords Alien freshwater turtle reproduction · Terrapins · Nest failure · Nest predation · Reproductive success

Introduction

Native to the USA and adjacent Mexico, *Trachemys scripta* (Thunberg and Schoepff 1792), commonly known as the North American pond slider, is considered the most ubiquitous, abundant, and invasive terrapin in the world (Parham et al. 2020). *Trachemys scripta*, and mainly the subspecies *elegans* (the red-eared slider), has dramatically expanded its global distribution due to the pet trade and is now present on all continents except Antarctica (Kitowski and Pachol 2009; Liuzzo 2020). The combination of low price, small size as juveniles, vivid coloration, and media influences (e.g., highly popular cartoons) has led to its global popularity as pets, with millions traded annually (Cadi et al. 2004; Bringsøe 2006). Sold as easy-to-keep pets at only a few centimetres in size, sliders are often released by their owners into natural and semi-natural wetlands when they get too large and require higher maintenance (Cadi and Joly 2003; Prévot-Julliard et al. 2007; Kitowski and Pachol 2009; Crescente et al. 2014; Maceda-Veiga et al. 2019).

Trachemys scripta elegans (Wied-Neuwied, 1839) had a wide natural distribution (Vamberger et al. 2020) in the USA

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even before industrial captive breeding and widespread introductions. There are, however, two other subspecies that have been introduced in the pet trade, and there is evidence of subspecies intermixing and hybridization, complicating the taxonomic picture (Parham et al. 2020; Vamberger et al. 2020). Due to their adaptability and potential for effective invasion if successful reproduction is established, pond sliders pose a significant environmental risk (Cadi et al. 2004; Kitowski and Pachol 2009; Ficetola et al. 2009). In Europe, they can alter aquatic communities and compete with native terrapin species (e.g., *Emys orbicularis* or *Mauremys* spp.) for resources such as food, basking places, and nesting locations (Cadi and Joly 2003; Standfuss et al. 2016). Additionally, they can act as significant disease vectors for native turtles (Demkowska-Kutrzepa et al. 2018). An import ban on the *elegans* subspecies was implemented within the European Union (EU) in 1997 and in Romania since 2007. However, trade has switched to other subspecies and similar species, from both North America and Asia, including several species with “serious risk of establishment” in the EU (Kopecký et al. 2013; Tietz et al. 2023).

In Romania, *T. scripta elegans* was only reported from urban areas (Sos 2007; Stănescu et al. 2020; Iftime and Iftime 2021),observed occasionally alongside other subspecies (*T. scripta scripta* and *T. s. troostii*), as well as several other non-native slider species (e.g., *Pseudemys concinna* and *Graptemys pseudogeographica*) (Iftime and Iftime 2021). Therefore, we use the term “sliders” to highlight the fact that our study refers to *T. scripta* without considering subspecies and acknowledges the potential presence of hybrids between them, while also differentiating them from the native pond terrapin. The reproduction of *T. scripta* in the wild has been reported in several European countries, including Austria (Kleewein 2014), Croatia (Koren et al. 2018), France (Cadi et al. 2004), Germany (Schradin 2020; Tietz et al. 2023), Italy (Ferri and Soccini 2003; Ficetola et al. 2003; Sperone et al. 2010; Crescente et al. 2014), Portugal (Martins et al. 2018), Serbia (Đorđević and Anđelković 2015), Slovenia (Vamberger et al. 2012; Standfuss et al. 2016), Spain (Silvestre et al. 1997; De Roa and Roig 1998; Bartolero and Canício 2000; Capalleras and Carretero 2000; Pleguezuelos 2002; Perez-Santigosa et al. 2008; Costa et al. 2016), and Turkiye (Çiçek and Ayaz 2015). While it was commonly assumed that *T. scripta* also breeds in Romania, given that juveniles were occasionally observed in the wild (Iftime and Iftime 2021), there were no documented reports of successful reproduction, and no data on nesting sites, egg-laying timing, or hatching rates.

This study aimed to investigate whether and how successfully this species breeds in Romania and to establish a baseline of nesting ecology information that can contribute to future management and help mitigate the environmental impact of this species.

Methods

Study area

The present study started in November 2022 on an artificial wetland lake at the Natural Science Museum Complex in Constanta (44°12’17.4"N, 28°38’25.9"E), an area designated to imitate Danube Delta habitats, with reed vegetations islands, in SE Romania. It has a surface area of 2 ha and a maximum depth of 1.5 m. The lake is located near the large inner-city Tăbăcăriei Lake (area 99 ha), part of a special protected area (ROSPA0057) and communicates with it through canals. Both lakes are inhabited by pond sliders (Fig. 1). It is considered a good habitat for pond sliders because it provides abundant food (including invasive fish species: *Pseudorasbora parva*, *Carassius gibelio*, and *Gambusia holbrooki*), and various places for basking, such as exposed banks, concrete surfaces, vegetation, or floating wood. It is also suitable for terrapin hibernation, given the deep layer of mud on the lake bottom.

Pond slider population

The persistence of large numbers of *T. scripta* in this area is attributed to the abandonment of previously captive pond sliders, but it has been speculated that some of the observed juveniles could have resulted from successful reproduction in recent years.

Adult sliders were captured using a gillnet (40 m long and 1.5 m high, with a mesh size of 8 cm), operated by a single person on 20 occasions, during November 2022-November 2023, except for the winter months (December-February), when there was no trapping. We measured their plastron length (PL) and straight carapace length (SCL) with a caliper (1 mm accuracy), weighed them with an electronic balance (1 g accuracy), and photographed them for later identification based on the dorsal pattern. Sex was determined based on morphological criteria such as plastron shape, claw size, and tail size (Gibbons and Lovich 1990). When possible, individuals were assigned to subspecies level using the characteristics reported by Powell et al. (2016) and Vamberger et al. (2020) and released at the site of capture.

Monitoring of terrapin nesting

We conducted nesting monitoring from the end of April until September 2023 with an average frequency of every two days. After the calculated 60th day of incubation, we conducted daily monitoring. We began the monitoring considering the weather (i.e., ~20 °C daily maximum temperatures in the last 10 days of April) and the nesting patterns reported from previous studies from Europe (e.g., Perez-Santigosa et al. 2008; Vamberger et al. 2012). To identify the slider nesting sites, we visually inspected the ground surface for signs of recently built nests, such as small patches of disturbed/wet soil or disturbed ground vegetation. When nests were identified, we measured the nests' diameter and depth using a calliper and recorded the nest exposure, the soil type, and the presence/absence of vegetation. We also recorded the exact location, using geographic coordinates in datum WGS84 (EPSG: 4326), recorded with a mobile application Geo Tracker (version 5.3.1.3446). Nests were classified into three categories: (i) abandoned – where the terrapin dug the nest but did not lay eggs and cover it; (ii) incomplete – where the terrapin dug the nest, covered it, but did not lay eggs; and (iii) complete – where the terrapin laid eggs and covered the nest.

Since human presence/disturbance can hinder the pond sliders' ability to nest (Liuzzo 2020), we avoided direct intervention during nesting. Despite conducting nearly daily surveys, we mainly relied on a passive approach, using camera traps in two terrestrial areas (marked 1 and 2, Fig. 1C) that we selected for observing terrapins laying eggs. The two areas are small islets with open vegetation, connected to the main terrestrial area by wooden boardwalks used as hiking trails. These areas were considered suitable for nesting due to their easily accessible areas of exposed ground with ample direct sunlight and proximity to water. We also selected the two areas based on discussions with the local staff regarding the places where female terrapins were observed laying eggs during the previous years. To cover the entire available ground surface, we deployed four camera traps in the first area and three in the second. The camera traps (PH770-5 S model) were set to capture one picture per minute. In both areas, we recorded the temperature every hour using HOBO Pendant MX loggers (MX2202 model) placed on the ground surface.

Nests identified in the two monitored areas were assigned an identification number based on the chronological order in which they were recorded (i.e., Nest 1, Nest 2). After using cameras and observing sliders laying eggs, we placed small cages above the nests (30 × 17 × 7 cm made of 13 mm^2 wire mesh, anchored in the ground) to deter egg predation on the complete nests and allow egg fertility assessments. Due to the prolonged incubation and hatching periods, at the expected end of the hatching period we excavated the completed nests and opened the eggs to determine the embryo stage, as is common practice (Perez-Santigosa et al. 2008; Lloyd and Warner 2019). We assigned development stages for eggs containing embryos according to Greenbaum (2002). Live hatchlings found were measured with a calliper (0.1 mm accuracy), weighed with an electronic balance (0.01 g accuracy), and photographed for later identification. To see if they could be recaptured, thus demonstrating winter season survival, they were released near the lake, ensuring they entered the water.

Data analysis

Analyses were conducted using R version 4.3.2 (R Core Team 2022). Descriptive statistics were calculated using the

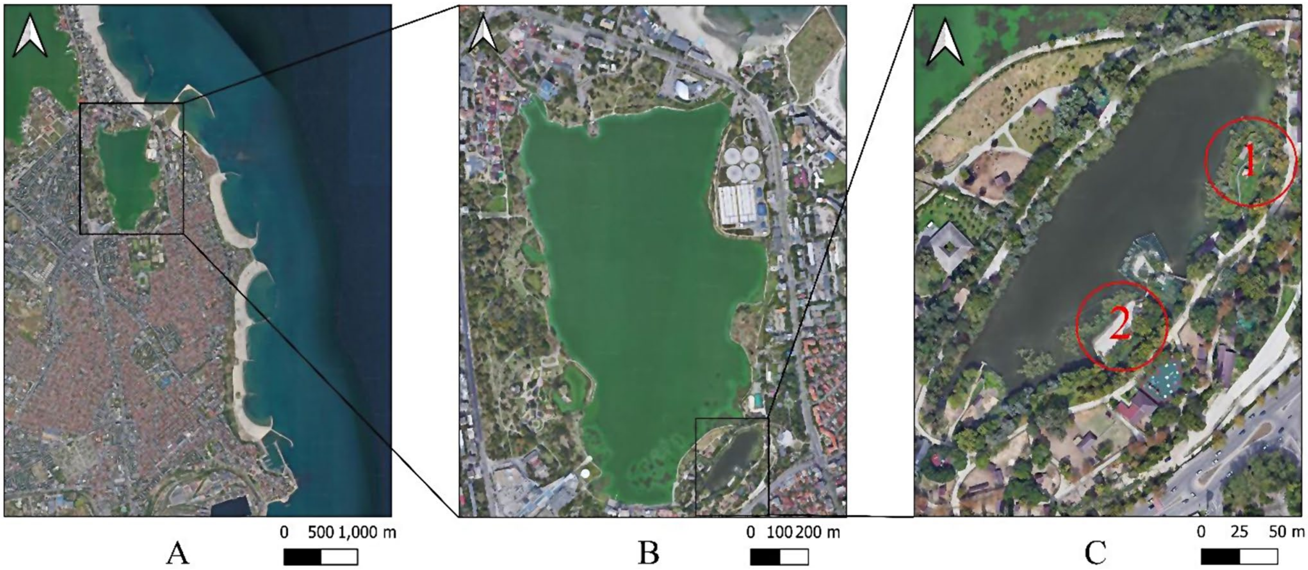

Fig. 1 Map of the Natural Science Museum Complex Lake in Constanta, Romania, featuring: **A**: The location of Tăbăcăriei Lake in Constanta City; **B**: The monitored area (in insert); and **C**: The two selected areas for nesting monitoring, marked as 1 and 2

‘sapply’ function from the *base* R package. We conducted a one-way ANOVA to test for differences in ground-level temperature between the two monitored areas. To determine the effects of nest exposure (exposed, partial, shadow) soil type (hard, medium, rock, soft), and vegetation type (dried, green, absent) on the number of nests, we performed generalised linear models (GLMs), fitted using the ‘*glm*’ function from the *base* R package, specifying a Poisson distribution and log link function. Because we did not a priori the sites for counting nests and recording the predictors, we considered all the combinations of the levels of the three predictors where at least one nest was found. This approach resulted in the identification of 16 sampling units. To evaluate the significance of model predictors we performed Wald likelihood-ratio chi-square tests (type III analysis of deviance) using the function ‘ANOVA’ from the “car” package (Fox and Weisberg 2019). For significant predictors, we performed Tukey’s post-hoc pairwise comparisons (Holm correction for multiple tests) using the ‘*glht*’ function in the ‘*multicomp*’ package (Hothorn et al. 2008).

Results

Adults

We captured a total of 78 pond sliders, 43 females and 35 males (sex ratio of males to females 0.81). Plastron length ranged from 163 mm to 244 mm (mean ± SD: 208 ± 17.33) for females and from 151 mm to 229 mm (170 ± 17.59) for males. The mean body mass of females was 1914.33 g (± 493.13; range: 967–3118 g), whilst for males the mean body mass was 884.06 g (± 269.34; range: 350–1981 g). Phenotypic characteristics suggested that not all individuals were red-eared sliders, and some might have been hybrids. We determined that 43.6% of the individuals were indeed *T. scripta elegans* and 14.1% were *T. scripta scripta*. The remaining individuals were either other subspecies or hybrids of the subspecies of *T. scripta* present at the site.

Nests

We identified a total of 43 nests (24 nests in area 1, 13 in area 2, and 6 outside the two monitored areas, Fig. 2), of which 13 were visually confirmed to have been built by invasive pond sliders. The other 30 nests were either located in areas not visually monitored or not within the angle of camera traps, hence species identities could not be confirmed. Six nests from area 2 were predated during the nesting process.

In total, eight confirmed slider nests were complete (of which one was predated), one nest was incomplete, and four nests were abandoned. Of the 30 additional nests, seven were complete, out of which five were predated, and 23 were abandoned. During the first recorded nesting attempt of a pond slider at the site, a hooded crow (*Corvus cornix*) disrupted the female slider and preyed upon the eggs in the nest. The crow took the eggs out of the nest, consuming a portion of them and causing the female slider to abandon the

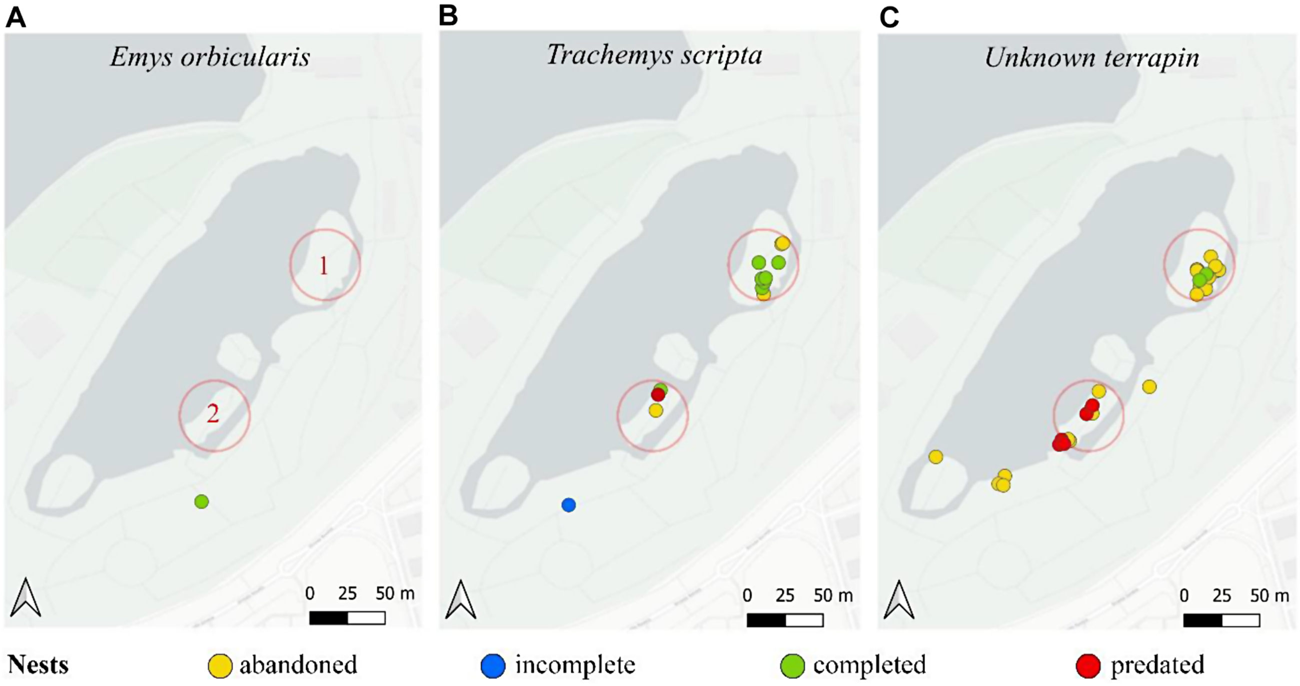

Fig. 2 Locations of nests categorised by type and taxa in the monitored areas marked as 1 and 2, **A**: *Emys orbicularis* nest; **B**: *Trachemys scripta* nests; **C**: unknown terrapin species nests

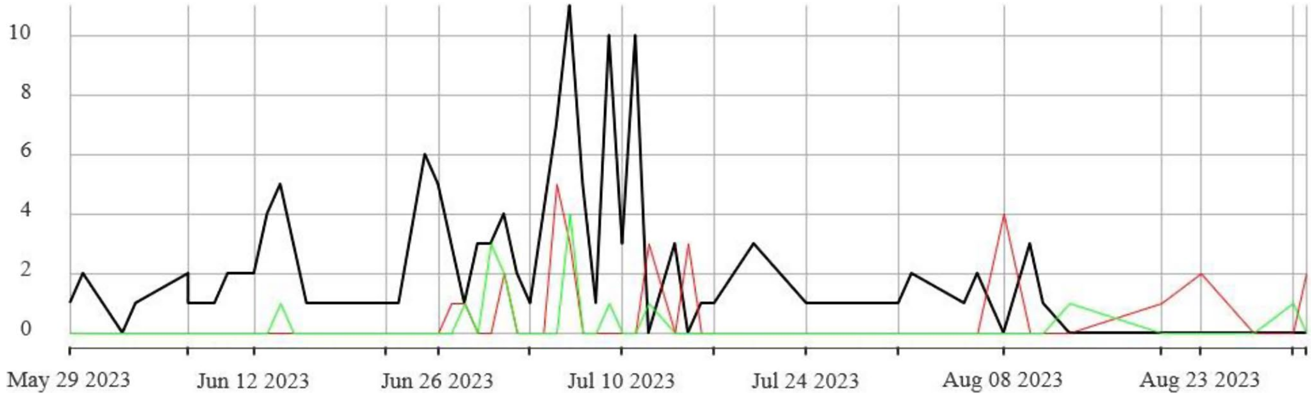

Fig. 3 The number of pond sliders observed on camera traps (black line); unidentified terrapin nests (red line), and confirmed *Trachemys scripta* nests (green line) during the monitoring period

Table 1 *Trachemys scripta* nests depth and diameter across the categories

Nr.	Nest category	Depth (cm)	Diameter (cm)
1	complete (preyed)	8	6
2	complete	12	7
3	complete	10	4
4	complete	12	7
5	complete	11	6
6	complete	13	-
7	complete	15	6
8	complete	15	6
9	abandoned	-	-
10	abandoned	-	-
11	abandoned	15	6
12	abandoned	11	6
13	incomplete	12	6

nest without covering it with soil. The egg predation continued on the second day, this time by a yellow-legged gull (*Larus michahellis*).

We identified terrapin nests from June 14 to August 31 (Fig. 3). We observed a single *E. orbicularis* female laying eggs on June 9, 2023.

To dig a complete nest, female pond sliders took between 70 and 112 min (mean ± SD: 87 ± 18.08), while it took between 4 and 83 min (38 ± 36.06) to dig nests to be abandoned. With the exception of Nest 8, in which eggs were laid at noon, sliders laid eggs either early in the morning or late in the afternoon.

The GLM analysis indicated that soil (Chisq = 16.913, df = 3, $P < 0.001$) and vegetation type (Chisq = 8.366, df = 2, $P < 0.05$) significantly influenced the number of nests in each subsampling unit, while exposure (Chisq = 4.9095, df = 2, $P = 0.09$) had a nonsignificant effect. Tukey's tests indicated significant differences in the total number of nests between soft (25% of total nests) and hard soil (44%) (mean difference ± SE: z = -2.696, $P < 0.05$), between green (38%) and dried vegetation (19%) (z = -2.259, $P < 0.05$), and between no vegetation (44%) and dried vegetation (19%) (z = -2.825, $P < 0.05$) (for all other pairwise combinations, $P > 0.05$).

Out of 13 nets that were confirmed as *T. scripta's*, we measured the dimensions of 11 nests. The depth varied from 8 cm to 15 cm while the diameter ranged from 4 cm to 7 cm (Table 1). The mean depth of complete nests was 12.57 cm (SD = 1.90), and the diameter was 6 cm (SD = 1.1).

Eggs

After a mean period of 78 days of incubation (mean incubation time ± SD: 78.5 ± 6.16 days), we excavated all complete nests. The average daytime temperature was higher, but not significantly, in area 1 (33.47 ± 13.31) compared to area 2 (32.55 ± 9.58) ($F_{[1,2327]} = 3.686$, $P = 0.055$). The average nighttime temperature was significantly higher in area 2 (22.86 ± 2.66) than in area 1 (19.14 ± 2.93) ($F_{[1,1331]} = 591.1$, $P < 0.05$).

The examination of the excavated nests (Table 2) revealed thirteen live hatchlings from Nest 2 and Nest 6, exhibiting an egg tooth and the yolk sac absorbed, identified as the subspecies *T. scripta elegans* as they presented the red-eared mark on their head. In Nest 2 and Nest 4, we found two hatchling skeletons within the dried eggshells and two partially emerged but dead hatchlings. The eggs from Nest 5 and Nest 7 were mainly dried out and affected by mould, with holes and a partly collapsed shape. We identified two eggs containing *T. scripta* embryos, in addition to the dried eggs in Nest 7 (Fig. 4).

Clutches from the eight complete *T. scripta* nests contained a total of 70 eggs with a median of 8.75 eggs per clutch, and of these, 18.57% hatched successfully (Table 2). The mean incubation time was 84 days (SD = 1.41) for the nests with hatchlings. It is worth noting that only the eggs from area 1 hatched.

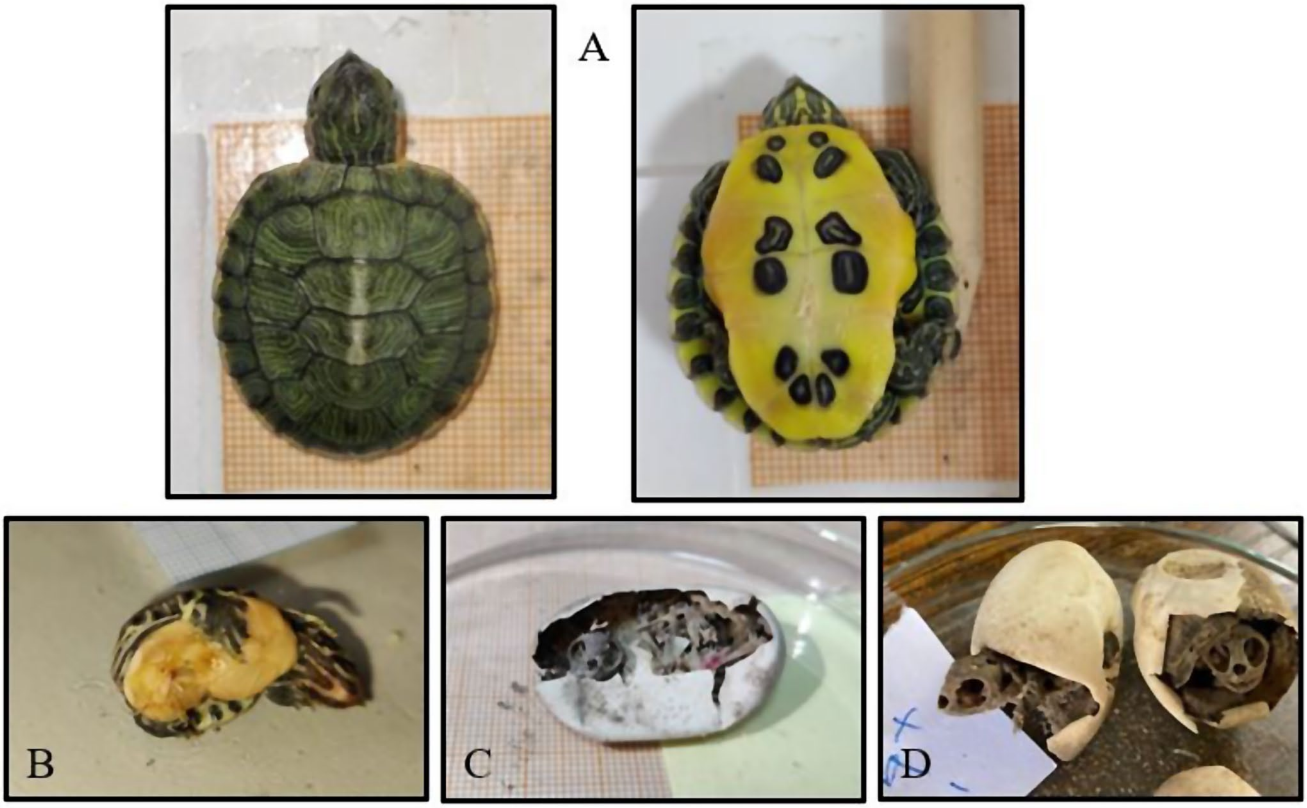

Fig. 4 Dorsal and ventral view of *Trachemys scripta* **A**: live hatchlings, **B**: embryo stage 24, **C**: deceased neonate (not emerged from the egg), and D: deceased neonates (partially emerged from eggs)

Table 2 Eggs, embryos, and hatchlings examined from the eight confirmed *Trachemys scripta* nests. Embryos were staged after Greenbaum (2002)

Nest ID	Area	Clutch size	Unhatched eggs	*N* hatched eggs	% hatched eggs	Notes
1	2	6	6	0	0	6 predated eggs
2	1	10	7	1	10	2 deceased neonates – partially emerged from eggs
3	1	8	8	0	0	-
4	1	8	6	0	0	2 deceased neonates – not emerged from eggs
5	2	12	12	0	0	-
6	1	12	0	12	100	-
7	1	12	10	0	0	1 individual in stage 24 1 individual in stage 22–23
8	1	9	9	0	0	-

The examination of eggs in the 30 additional nests revealed that in one of them, six eggs were non-viable and appeared to be infertile. However, fresh eggshells and the opening from the inside indicated that hatchlings recently emerged from one of these nests. We could not confidently assign the nests to one of the two main terrapin species present (native or invasive).

Hatchlings

The straight carapace length of the 13 hatchlings ranged from 28.6 mm to 31.9 mm (mean ± SD: 30 ± 0.1), and their body mass ranged from 5.7 g to 7.4 g (6.58 ± 0.59).

The mean carapace length of hatchlings in our study was similar to those of hatchlings from *T. scripta* native populations ($P = 0.861$) (Janzen et al. 2000) and some non-native populations like the one from Germany ($P = 0.4$) (Schradin 2020) but significantly larger ($P < 0.001$) compared to other non-native populations like those from Italy (Ferri and Soccini 2003), Spain (Perez-Santigosa et al. 2008) and Austria (Kleewein 2014).

Discussion

Our study has provided evidence that *T. scripta* can successfully reproduce in Romania, in addition to studies published from nearby countries like Serbia (Đorđević and Anđelković 2015; Urošević et al. 2019) and Bulgaria (Kornilev et al. 2020). The observed success rate in our study was relatively low but, for confirmation, more data are needed, across multiple years and sites. The strategy for most invasive species is based on their wide environmental tolerance, high growth rate, high reproductive capacity, and competitive ability (Whitney and Gabler 2008). The present observation of the successful breeding of *T. scripta* in SE Romania suggests the potential for self-sustaining and possible expansion of feral populations. Although abandonment of previously captive pond sliders is likely responsible for the establishment and the presence of a large number of adults in this local pond slider population, as some individuals potentially survived for decades, the population dynamic might change substantially if they successfully adapt to the local environment and reproduce naturally. Furthermore, introduced pond slider populations can also expand their range through migration as a second phase of biological invasion and dispersal without human intervention (Ficetola et al. 2009; Koo et al. 2019).

Previous studies have shown that the size of sexually mature females of *T. scripta* varies widely among populations and subspecies, both within their native range (Gibbons and Greene 1990; Close and Seigel 1997; Aresco 2004) and outside it (Perez-Santigosa et al. 2008). In North America, females reached sexual maturity at a plastron length of 160–170 mm, while in southern Spain, sexually mature females had a plastron length of 160 mm (Perez-Santigosa et al. 2008). Thus, the initial results indicate that female sliders from our study do not exhibit significant differences ($P = 0.213$) in mean plastron length compared with females from some native populations (Tucker and Moll 1997) but are significantly different ($P < 0.001$) from other native-range populations (Tucker et al. 1998; Hays and McBee 2010) and also from some non-native populations, such as those in Spain (Perez-Santigosa et al. 2008).

Our data does not support the early maturity attributed to invasive populations of *T. scripta* (Perez-Santigosa et al. 2008) but this needs further verification given that it includes results from a single site and a single nesting season.

If reproduction starts early, it may benefit the initial establishment of these populations (Perez-Santigosa et al. 2008). Our study showed that the nesting period lasted for 2.5 months, from mid-June to the end of August in 2023, shorter than in the native range (mid-April–early August) (Aresco 2004) and introduced European slider populations such as Spain (April–July) (Perez-Santigosa et al. 2008), France (May–August) (Cadi et al. 2004) and Italy (May–July) (Crescente et al. 2014).

Pond slider females have been documented to actively select their nest-site locations (Wilson 1998; Tucker 2000; Lloyd and Warner 2019). For example, Lloyd and Warner (2019) found that females prefer to nest in open areas characterised by the highest temperatures, a crucial factor for the survival of the species, and with fewer predators. Our results suggest that terrapins exhibit a preference for nesting in areas with hard soil and green vegetation, or without vegetation in open areas, but how this might influence emergence remains unknown.

We observed a high proportion of abandoned nests (63%). Abandoned nests were described as “false nests”, when the terrapin leaves without depositing any eggs (Christens and Bider 1987; Wilson 1998; Washington 2008). For painted turtles, the apparent reason for leaving the nest with no eggs laid is not the soil type (Christens and Bider 1987), but a more complex nest-site selection that could also include the presence of predators (Wilson 1998). In both monitored areas, our records of abandoned nests did not show sliders being disturbed during nesting by animals or humans.

In Germany, there were up to 24 eggs in a clutch of *T. scripta* (Schradin 2020), while in southern France, the clutch size varied between four and 11 eggs (Cadi et al. 2004). In our study, the clutches consisted of 6 to 12 eggs. However, females can lay eggs whether or not they are fertilised, and it is important to verify if fertilised eggs would develop successfully under different climatic conditions outside their native range, like in Romania. The hatchlings or embryos in various stages of development in 50% of the inspected nests showed that eggs were indeed fertile, and the reproduction was successful.

Hatching success in our dataset ranged from 0 to 100% between nests. However, it remains unknown whether hatchlings would have emerged in autumn or overwintered in the nest and emerged the following spring, as *Trachemys* spp. usually overwinter in the nest after hatching (Janzen et al. 2000; Tucker 2000; Ficetola et al. 2003).

Substrate moisture has been shown to affect hatching success in turtles (Ficetola et al. 2009), with a moist substrate being crucial for embryonic development, yet we observed a moist substrate only in the *E. orbicularis* nest. In addition to substrate moisture, incubation temperature has an important effect on most development parameters, including embryo survival (Wilson 1998) and progeny sex for this species with temperature-dependent sex (Ewert et al. 1994). The persistence of pond sliders outside their native range may be attributed to nest-site selection, which influences the microclimate experienced by embryos. Thus, nest-site selection may play an important role in embryo survival and the establishment success of this invasive species (Wilson

1998; Lloyd and Warner 2019). In addition, given that sliders have temperature-dependent sex determination, the sex ratio can be heavily biased in areas of introduction where climatic conditions are different compared to the native range, as observed in Japan, where the sex ratio was heavily female-biased and thus productivity is higher (Taniguchi et al. 2017).

The presence of reproductive populations of *T. scripta* is correlated with climatic features such as a warmer climate, increased solar radiation, and higher precipitation compared to populations where reproduction is not observed (Ficetola et al. 2009). Ongoing global warming may enhance the successful reproduction of this species in invaded ranges, especially during particularly warm years. In our study area, characterised by mild winters and dry summers, the apparent suitability for reproduction is high.

Nest predation in turtles is one of the leading causes of mortality at the egg stage (Spencer 2002). In their native range, pond sliders are susceptible to predation by a wide variety of predators, including coyotes (Minckley 1966), raccoons (Seigel 1980), and birds (Janzen et al. 2000). Outside their native range, predators also play a crucial role in limiting and decreasing terrapins' reproductive success (Spencer 2002). Hatchlings are assumed to face high predation pressure, but only a few observations of predation on pond slider hatchlings have been reported (Britson and Gutzke 1993; Mačát and Jablonski 2016). Although we covered the slider nests with nets, we did not observe predation attempts on the completed nests after the female succeeded in covering the eggs. Nest predation was observed when the female was disturbed during the laying of the eggs, which is consistent with previous research from native ranges (Aresco 2004).

Conclusions

To our knowledge, this is the first documented observation of nesting ecology that proves that *T. scripta* successfully reproduces in Romania. The presence of numerous viable hatchlings in multiple nests necessitates the management of sliders in Romania to become active rather than passive. Allowing abundant slider populations to persist in numerous urban and peri-urban areas of the country in the hope that, as they are banned from trade, they will naturally die out in time is not an option if they successfully reproduce in the wild. This is particularly relevant in areas well-connected to other water bodies, which enables further spread in the wild.

Pond sliders remain generally popular with the public, some of whom are unaware that these are invasive species, and mass removal of sliders would likely create a public backlash and possibly further negative impacts (e.g., people illegally translocating sliders away from areas of control). It is, therefore, necessary to accompany management interventions with public awareness-raising campaigns, emphasising the importance of the management of invasive species and responsible pet ownership. Despite regulations banning the importation, trade, and breeding of *Trachemys scripta elegans* in the European Union, the result so far is simply a shift in the species being traded, raising further environmental problems and threats to native fauna (Maceda-Veiga et al. 2019). We advocate for a wider ban on the pet trade of terrapins with invasive potential and the control of existing established populations, especially in areas where they can successfully reproduce.

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Author contributions DC, GF, and LR contributed to the study conception and design with guidance from SP. Field work was done by GF and MV, and partially by SV and OD. GF and RB performed the analysis. The first draft of the manuscript was written by GF with guidance from SP and all authors participated in the final version of the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate Permits were issued by the Ethical Committee of the Faculty of Natural Sciences and Agricultural Sciences, Ovidius University of Constanta.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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