BioInvasions Records (2021) Volume 10, Issue 3: 721–729

Rapid Communication

First successful reproduction of the Chinese striped-necked turtle *Mauremys sinensis* (Gray, 1834) in a European wetland

Laura Di Blasio[1], Riccardo Santoro[2], Vincenzo Ferri[3,4], Corrado Battisti[5], Christiana Soccini[3], Alessandro Egidi[1] and Massimiliano Scalici[1,*]

[1]*Università degli Studi Roma Tre, Dipartimento di Scienze, viale Guglielmo Marconi 446, 00146 Rome, Italy*
[2]*via Eugenio Maccagnani 55, 00148 Roma, Italy*
[3]*via Valverde 4, 01016 Tarquinia (Viterbo), Italy*
[4]*L.Z.B.E., Department of Biology, Univ. Roma 2 "Tor Vergata", via Cracovia 3, Roma, Italy*
[5]*"Torre Flavia" Long Term Ecological Research (LTER) Station, Città Metropolitana di Roma, via Tiburtina, 691, 00159 Roma, Italy*

Author e-mails: *rsantoro490@gmail.com (RC), drvincenzoferri@gmail.com (VF), c.battisti@cittametropolitanaroma.gov.it (CB), ch.soccini@gmail.com (CS), lau.diblasio@stud.uniroma3.it (LDB), ale.egidi1@stud.uniroma3.it (AE), massimiliano.scalici@uniroma3.it (MS)*

**Corresponding author*

Citation: Di Blasio L, Santoro R, Ferri V, Battisti C, Soccini C, Egidi A, Scalici M (2021) First successful reproduction of the Chinese striped-necked turtle *Mauremys sinensis* (Gray, 1834) in a European wetland. *BioInvasions Records* 10(3): 721–729, https://doi.org/10.3391/bir.2021.10.3.22

Received: 12 October 2020
Accepted: 5 February 2021
Published: 3 July 2021

Handling editor: Rui Rebelo
Thematic editor: Michal Janáč

Abstract

Alien species are considered one of the main threats to biodiversity, and amongst them turtles are the most traded taxon worldwide. We are reporting observations on the Chinese striped-necked turtle (*Mauremys sinensis* Gray, 1834) and particularly the first evidence of reproduction in a European wetland. During an eradication project of non-native turtles, underway since 2019, we observed a hatchling of *Mauremys sinensis* in the Torre Flavia wetland (Tyrrhenyan coast of Central Italy). This finding suggests the naturalization of the local population, requiring increased attention since the disturbance by *M. sinensis* adds to that of the invasive population of *Trachemys scripta* in the study area. In the absence of control and management on introduced nuclei, this situation can lead to a widespread naturalization of *M. sinensis*, with detrimental and irreversible impacts on endangered native taxa such as *Emys orbicularis*.

Key words: invasion, eradication project, remnant wetland, *Emys orbicularis*

Introduction

The introduction of alien species and the ensuing competitive interactions with native taxa are considered among main factors of biodiversity loss (Hobbs 2000; Mooney et al. 2005; Hulme et al. 2009; Butchart et al. 2010), a feature that is also reported in freshwater ecosystems (Genovesi 2007; Francis 2012; Di Santo et al. 2017). Several of these species are exotic vertebrates, including reptiles, intentionally introduced (mainly through the trade of farm and pet animals) that end up in the natural environments, after escape from captivity or intentional release (Kraus 2009; van Wilgen et al. 2010; for freshwater habitats see: Kopecký et al. 2013).

Turtles are among the most traded reptiles worldwide. An example of this trade was *Trachemys scripta elegans* (Wied-Neuwied, 1839) of which

more than 52 million individuals were exported from the U.S.A. in the period 1989–1997 (Masin et al. 2014; Ferri and Soccini 2008). In 1997 the European Union (EU) blocked its trade (EU Regulation 338/1997; EU Regulation 349/2003) because of the high risk of biological invasion, but this shifted the attention to other subspecies: *Trachemys scripta scripta* (Thunberg in Schoepff, 1792) and *Trachemys scripta troostii* (Holbrook, 1836). The definitive ban of the trade of *Trachemys scripta* (Thunberg in Schoepff, 1792), in force since 2015 in the EU (EU Regulation 1143/2014) has definitively shifted the market to other species of pet turtles (Hulme 2015). The new regulation has unfortunately diverted the buyers to other species with morphological and biological characteristics that make them suitable invaders (fast growth, large size and aggressiveness; Ferri et al. 2019). In fact, their sale has always concerned small juveniles at cheap price (Masin et al. 2014). Consequently, the first reports of reproductive success in natural environments are now being recorded for the most traded species, which are concerning not only the turtles that were considered at the top positions in the evaluation of the invasiveness risk (e.g. *Pelodiscus sinensis* Wiegmann, 1835; Masin et al. 2014), but also species that were considered of low risk for the European wetlands, such as *Graptemys pseudogeographica* (Gray, 1831) (Ferri et al. 2019) and *Mauremys sinensis* (Gray, 1834).

The Chinese striped-necked turtle *Mauremys sinensis*, representative of Geoemydidae family, is widely distributed in the subtropical regions of Taiwan, in South-eastern China, in the Eastern Laos and Northern and Central Vietnam (van Dijk et al. 2014). The species has been largely introduced worldwide (e.g. Probst and Sanchez 2013). It is a species well adapted to a wide range of climatic conditions, including the southern temperate and subtropical zones, where it inhabits various habitats, including ponds, lakes, reservoirs, irrigation ditches and low-lying rivers (Ernst et al. 1997; Chen and Lue 2009). Natural populations have suffered a serious decline in much of their native area (Chen et al. 2000), being victims of overconsumption for the food and medicine markets and pet trade (Gong et al. 2009). In addition, its natural habitat is shrinking due to human development (Chen and Lue 2009).

Although *Mauremys sinensis* is protected by CITES (Appendix III – China) and considered an Endangered species by the IUCN (Buhlmann et al. 2000), it remains one of the most common pet turtle (CITES 2000). This species is largely bred in "turtles-farms", especially in China and Taiwan. A minor part of the farmed turtles ends up in Europe to be sold in the pet market at an attractive price. The species is hardy and survives to various circumstances even if in the hands of children or beginner hobbyists.

European *Mauremys sinensis* records in natural habitats comprise two findings for Portugal in July 2019, seven for Spain, from 2014 to 2019 (LIFE09 NAT/ES/000529), one for Poland (Marini 2017), one in Slovakia

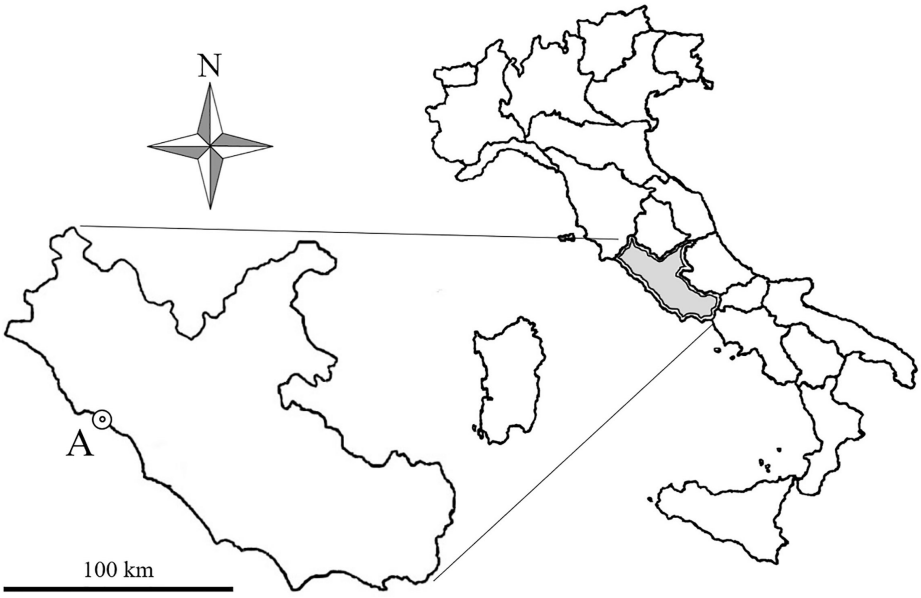

Figure 1. Study area (Torre Flavia wetland, Latium, central Italy). Location of the coastal study site (A). On the right: geographic location within Italy.

(Jablonski et al. 2018), and several findings (always a single individual) in urban ponds in Italy: from Brescia (V. Ferri, *pers. comm.* 2019); in Rome (R. Santoro, *pers. comm.* 2019); near Trento and in Ferrara (GBIF 2020); and in Palermo Botanical Garden (Panzeri et al. 2014).

In this note we report the observation, for the first time in a European wetland, of hatchling of *Mauremys sinensis* in a wild context, made during an eradication project of alien turtles carried out within a central Italian preserved area having the highest number of introduced turtle species (Ferri et al. 2020a, b). We report also morphometric data about two other individuals of this alien species (adults), observed and captured in the same wetland.

Materials and methods

In spring 2020 we started a management project focused on the control of alien turtles in the Torre Flavia wetland, a Special Area of Conservation (code IT 6030020) according to the EU Directives 79/409 and 147/2009/CE, consisting of 40 ha of wetland located on the Tyrrhenian coast (Central Italy; coordinates: 41°58′N; 12°03′E; Figure 1).

From a bioclimatic point of view, the area belongs to the meso-Mediterranean xeric region (Blasi and Michetti 2005). It represents the remnant of a larger wetland, partially drained and transformed in the last fifty years, where water is mainly of rain and sea storm origin and flow from surrounding areas is scarce. Water depth varies with the seasons: from October to March the flood level reaches the maximum value (70 cm), while from June to October it is reduced to form some areas of muddy soil or shallow ponds (Battisti et al. 2006; Zacchei et al. 2011; seasonally flooded wetland *sensu* Cowardin et al. 1979). The study area shows semi-natural

Figure 2. *Mauremys sinensis* hatchling found in Torre Flavia. It is seriously injured on the tail and on the front of the head: wounds compatible with an attack by ants at the time of hatching and exiting the nest. Photo by C. Battisti.

patchiness, being composed of (i) reed beds dominated by *Phragmites australis* (Cav.) Trin ex Steudel, which are cut off by water basins, such as ponds and channels, (ii) flooded meadows dominated by the two typical taxa *Juncus* sp. and *Carex* sp. of the vegetal association *Juncetalia maritimi* (habitat type of conservation concern according to 92/43 "Habitat" CEE directive), and (iii) coastal dunes (Battisti 2006; Santoro et al. 2012). The surrounding matrix is a mosaic of cultivated and uncultivated fields, adjacent to human settlements. This area is known as a xeno-diversity hot-spot, hosting assemblages rich in non-native species (Amori and Battisti 2008).

We carried out random sampling using basking-traps in a set of representative sites along the banks of the wetland channels with presence of extensive reedbeds of *P. australis.* The basking trap is a floating enclosure with sloping sides and a basking surface. Turtles are able to climb up the sloping sides onto the basking surface, but then when they jump off into the center, they cannot get back out (Gamble 2006). However, when occurring, we recorded individuals also using an opportunistic sampling technique. Specifically, five traps were located within the study area when the water depth was at least 50 cm. Once captured, the specimens were measured and photographed (both carapace and plastron).

Results and discussion

In September 30th 2020 we recorded a hatchling of *Mauremys sinensis* (Figures 2, 3; Table 1), captured along a sandy path bordering a *P. australis*

Figure 3. Ventral photograph of hatchling *Mauremys sinensis* found in Torre Flavia. Wounds on the tail are clearly visible. On the right, on the plastron, the umbilical scar has almost completely healed, a sign that the hatching took place at least ten days before the discovery. Photo by C. Battisti.

Table 1. Biometric data collected on individuals of *Mauremys sinensis* (Gray, 1834) observed in the study period (2017–2020) in the Torre Flavia wetland (CL = straight carapax length; CW = carapax width; PL = plastron length; PW = plastron width; W = weight).

specimen (date)	CL (mm)	CW (mm)	PL (mm)	PW (mm)	W (g)
female (May 2017)	111.10	80.00	96.00	66.70	68.00
male (June 2020)	162.00	108.00	156.00	105.20	840.00
hatchling (October 2020)	29.00	22.00	23.00	20.00	6.00

reedbed (coordinates: 41°57′32,5″N; 12°03′05,4″E). The hatchling had the umbilical scar and it had not growth rings on the carapace (Figure 2). In 2017 we opportunistically captured a female (Figure 4) of this species (see Ferri et al. 2020a). In June 2020 another adult specimen of this species (male, Figure 5) was trapped in one of the basking traps. The sizes of the captured specimens (see Table 1) are within the range known for the species (van Dijk et al. 2014). Indeed, *Mauremys sinensis* shows a carapace length of 95.2–198.4 mm in males, with females slightly larger reaching 269.6 mm (Chen and Lue 1998).

This record of *Mauremys sinensis* natural reproduction was the first in Italy (Panzeri et al. 2014). The presence of both hatchlings and adults leads to hypothesize that there may be a naturalized local population, suggesting that without an intensive control of the introduced nuclei, this situation can lead to a widespread naturalization of this species *Mauremys sinensis* in the study area. This would be alarming, given that the spread of an invasive population of *Trachemys scripta* has already been recorded there. Joint impacts of the non-native turtle populations then can negatively affect the native freshwater fauna and residual population of the European pond turtle (*Emys orbicularis*), the only native turtle species in the area.

Figure 4. Dorsal (on the left) and ventral (on the right) photos of a sub-adult female of *Mauremys sinensis* captured in Torre Flavia in May 2017, and died in captivity at the beginning of 2019. Photographs by V. Ferri and R. Santoro.

Figure 5. Dorsal and ventral photo of an adult male of *Mauremys sinensis* captured in Torre Flavia in June 2020; the individual is currently housed in an alien turtle recovery center. Photographs by V. Ferri and R. Santoro.

According to Van Wilgen et al. (2010), turtles considered to have a high risk of invasion can become naturalized in areas with a suitable climate even with the introduction of only two individuals per year. However, the lack of climatic suitability in the introduction area or the low risk of invasion does not guarantee that a species cannot be successfully established if propagule pressure is high. Some species—and this is the case of the genus *Mauremys*—could be able to exploit environmental conditions that are not available in their native area and start evolutionary processes that are still little known and could allow adaptations to new climates

(Lockwood et al. 2005; Broennimann et al. 2007). This is the case of *Mauremys sinensis*, which was found to have suitable areas for invasion mostly in tropical regions, according to the risk assessment carried out by Masin et al. (2014). Its extensive distribution, however, provides an evidence that the species is tolerant to a wide range of temperatures (see also Pan et al. 2003).

The morphological analysis of the hatchling cannot exclude hybridization with other *Mauremys* species (such as *Mauremys reevesii* Gray, 1831), which is common for this species (Xia et al. 2011; Lee et al. 2019). In fact, recent research in Taiwan suggests that *Mauremys sinensis* can reproduce in nature with *Mauremys reevesii*, producing fertile hybrid offspring (Fong and Chen 2010; Suzuki et al. 2011). However, the only native Italian species *Emys orbicularis* cannot hybridize with *Mauremys sinensis*.

It is difficult to say whether, due to the continuous release, *M. sinensis* will establish local populations in Europe and what the impact of this alien species will be on the native biota. In this regard, we reiterate how it is necessary to ban the import of this species, increase customs controls, and monitor the Mediterranean marshes. At local level, a multi-year program of capture and control of exotic turtles is already active in the study area, aimed at eradication of all alien species (*sensu* Genovesi 2005). Further research is needed locally to understand why there are so many species of exotic turtles, the causes of introduction and what the impacts may be on the protected area.

As regards the national level, the species will be included in the Black List of invasive alien fauna species (IAS) for Italy (Vincenzo Ferri *pers. comm.*), which will integrate the list of IAS of Union importance produced by European Union and which will be submitted to the Ministry of the Environment and the Protection of the Territory and the Sea for the implementation of the European Regulation 1143/2014 and of the Legislative Decree 230/2017.

Acknowledgements

We are indebted to Erica Meloni (University of Tuscia, Viterbo) and Alessia Mircoli (University Roma Tre, Rome) for their support in the field working. This investigation was supported by the Grant of Excellence Departments, MIUR-Italy (Art. 1, C. 314 – 337 Law 232/2016). Two anonymous reviewers and the Editor provided useful comments and suggestions that improved the first draft of the manuscript.

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