

Alien chelonians in north-eastern Spain: new distributional data

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INTRODUCTION

Alien species pose a growing threat to native biodiversity because of their role as competitors, predators or as vectors of disease (Tompkins et al., 2003). In north-eastern Spain, aquatic ecosystems have been colonised by numerous alien species, including crustaceans, fishes, amphibians and reptiles (Clavero & García-Berthou, 2003; García-Berthou et al., 2007; Escoriza & Boix, 2012). These aliens may have an important effect on native biotic communities and although this impact has been widely studied in fish and amphibians, it is less well known in reptiles (Escoriza, 2018).

Catalonia in the north-east of Iberian Peninsula is relatively rich in reptile species (Salvador, 2014). In this region there are three species of native chelonians (*Emys orbicularis*, *Mauremys leprosa* and *Testudo hermanni*), with small and fragmented populations, that are sensitive to potential disturbances in habitat quality (Pleguezuelos et al., 2002; Couturier et al., 2014). Consequently, it is a conservation priority to assess the occurrence of alien species that may occupy similar habitats and to determine whether they have established successful breeding populations. Since the beginning of this century alien chelonian species have increased in number and in geographical range in the region but there has been no formal report drawing all the observations together.

The first records of alien turtles are from the mid-1990s. *Trachemys scripta* was the most widely distributed alien species, although restricted to the coastal regions of Barcelona and Girona (Llorente et al., 1995). Subsequently, other species of freshwater turtles were observed around Barcelona and its periphery: *Pseudemys concinna floridana*, *Chrysemis picta* and *Graptemys pseudogeographica* (Filella et al., 1999). Around the late 1990s, *Chelydra serpentina* was also observed in the locality of Castell d'Aro (Girona) (D. Boix, unpublished data). In 2010, three additional species were reported in Castellet (Barcelona): *Trachemys decussata*, *Mauremys reevesii* and *Pelodiscus sinensis* (Martínez-Silvestre et al., 2010).

In addition to the progressively increasing diversity of

aliens, some species have also shown an important and rapid expansion of their local range, especially *T. scripta* (Llorente et al., 1995; Filella et al., 1999). In the case of the terrestrial chelonians, most records refer to *Testudo graeca*, but there are also sporadic citations of other species: *Terrapene carolina*, *Testudo hermanni boettgeri*, *Testudo horsfieldii*, and *Testudo marginata* (Soler et al., 2010).

MATERIAL & METHODS

In the present study, we monitored the occurrence of alien turtles and tortoises in the provinces of Girona and Barcelona during the period 2000-2019. The habitats surveyed were mainly wetlands including rivers, lakes, reservoirs and artificial ponds located in natural reserves, river deltas and urban parks. The habitats were not chosen because they already had a record of the presence of an alien species. The surveys were undertaken using visual transects with binoculars and using baited funnel traps (Escoriza et al., in press). Terrestrial species were opportunistically located during these surveys. Taxonomy follows Uetz et al. (2019), and specimens were identified to species level following Bonin et al. (1996), Conant & Collins (1998) and Ernst & Lovich (2009).

Details of the chelonian records, on which this study is based, are presented in Supplementary Material on the British Herpetological Society website (see note at the end of this article).

RESULTS

Seventeen species of alien freshwater turtles and three species of terrestrial tortoise have been detected in the provinces of Girona and Barcelona. A preliminary assessment of the data obtained during the surveys showed a positive trend in both the richness of alien species and the number of sites occupied by them (Table 1 and 2, Fig. 1). *Trachemys scripta* is the most widely distributed species in our study area (Fig. 2) and it is also the only species in which reproduction has been confirmed (see Supplementary Material). The other species

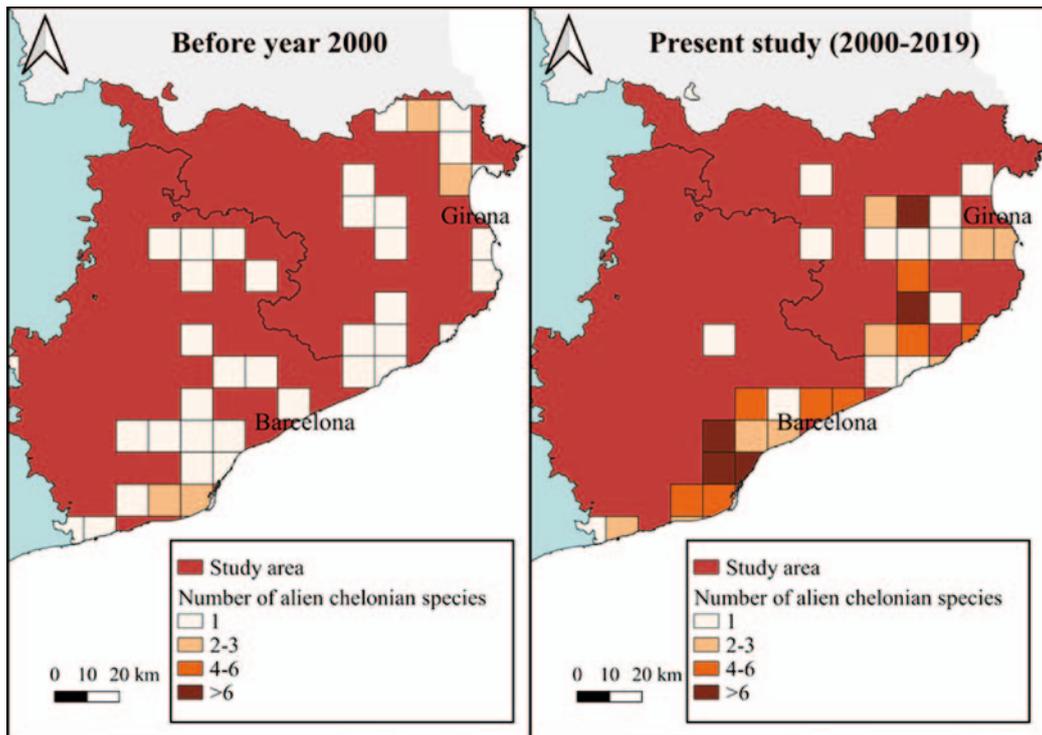


Figure 1. Map showing previous and new chelonian records in the study area. On the left side is shown a compilation of two publications (Llorente et al., 1995; Filella et al., 1999), with the species richness of alien chelonians. On the right side is shown the number of alien chelonian species, based on the new data collected in this study.

Table 1. Alien chelonian species detected in Girona and Barcelona

Species	Period of observation	No. of sites
<i>Apalone ferox</i>	2013	1
<i>Chelydra serpentina</i>	2001-2016	5
<i>Chrysemis picta</i>	2011-2019	3
<i>Graptemys ouachitensis</i>	2014-2018	4
<i>G. pseudogeographica</i>	2007-2019	19
<i>Kinixys belliana</i>	2018	1
<i>Macrochelys temminckii</i>	2013	1
<i>Mauremys mutica</i>	2018-2019	1
<i>M. reevesii</i>	2016-2019	6
<i>M. sinensis</i>	2013-2019	12
<i>Pelodiscus sinensis</i>	2012-2019	2
<i>Pseudemys concinna</i>	2003-2019	19
<i>P. nelsoni</i>	2011-2019	20
<i>P. rubriventris</i>	2019	1
<i>Sternotherus odoratus</i>	2013-2018	2
<i>Testudo graeca</i>	2003-2006	2
<i>T. horsfieldii</i>	2016	1
<i>Trachemys grayi emolli</i>	2011-2019	6
<i>T. ornata</i>	2013	1
<i>T. scripta</i>	2001-2019	61

Table 2. Number of alien chelonian species and sites, in Girona and Barcelona during the period 2001-2019

Year	No. of alien species	No. of sites
2001	2	2
2002	1	1
2003	3	3
2004	2	4
2005	1	1
2006	2	2
2007	2	1
2008	2	3
2009	2	2
2010	3	3
2011	7	8
2012	8	15
2013	12	13
2014	8	14
2015	8	20
2016	10	21
2017	5	18
2018	12	25
2019	11	27

show a more restricted distributional range, mostly localised in urban or peri-urban areas, although their range also has increased in the last decade. This is particularly evident in *Graptemys pseudogeographica* and *Pseudemys nelsoni*. Both species were only occasionally recorded before 1999 (Filella et al., 1999) but presently appeared in 7 % and 9 % of the region (Fig. 2).

Semi-aquatic turtles have been found and these are mainly species of east Asian and North American origin (Table 1), from subtropical to temperate climates (Bonin et al., 1996; Ernst & Lovich, 2009), but also include one strictly tropical species (*Trachemys grayi emolli*; Table 1, Fig. 2 and Fig. 3). During the surveys we detected, for the first time in Europe, free-living *Mauremys mutica* (Table 1, Fig. 2 and Fig.

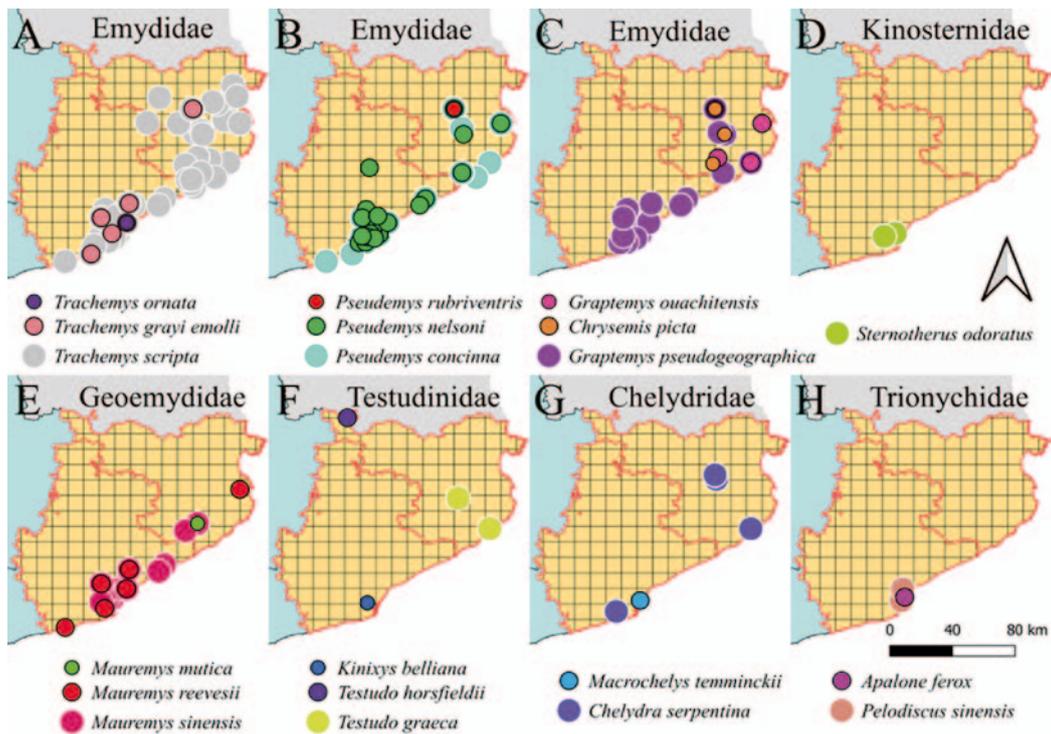


Figure 2. Map showing the records of the alien species. **A.** *Trachemys*; **B.** *Pseudemys*; **C.** *Graptemys* and *Chrysemis*; **D.** *Sternotherus*; **E.** *Mauremys*; **F.** *Kinixys* and *Testudo*; **G.** *Macrochelys* and *Chelydra*; **H.** *Apalone* and *Pelodiscus*



Figure 3. Examples of alien species of chelonians found in Girona and Barcelona. **1.** *Chelydra serpentina*; **2.** *Pseudemys concinna*; **3.** *Mauremys sinensis*; **4.** *M. mutica*; **5.** *Sternotherus odoratus*; **6.** *Trachemys scripta*; **7.** *Chrysemis picta*; **8.** *Graptemys pseudogeographica*; **9.** *P. nelsoni*; **10.** *M. reevesii*; **11.** *Pelodiscus sinensis*; **12.** *Macrochelys temminckii*; **13.** *Testudo horsfieldii*; **14.** *T. graeca*; **15.** *T. grayi emolli*.

4), a species native to the subtropical regions of south-east Asia (Bonin et al., 1996). We marked the specimen and then recaptured it in two consecutive years, indicating that it is capable of withstanding the mild winter conditions of the

region. We also detected two adult specimens of *Pseudemys rubriventris* (male and female) in the Lake Banyoles (Table 1, Fig. 2 and Fig. 4). This is only the second record of this species in the Iberian Peninsula (Arribas, 2017) and the first record outside an urban environment.

During the surveys we also observed some isolated specimens of three alien species of land tortoise *T. graeca*, *T. horsfieldii*, and *K. belliana* (Table 1, Fig. 2 and Fig. 3); there was no evidence that these species were reproducing. *Testudo graeca* was found in several peri-urban locations and possibly these specimens had survived for long periods in the region. *Testudo horsfieldii* is native to the continental steppes of south-western Asia and appears very frequently in the pet trade (Türkozan et al., 2008). During our surveys it was observed only on a single occasion, in an agricultural field near to the city of Puigcerdà (Fig. 3, and see Supplementary Material). Also a single specimen of *K. belliana* was observed in an urban park in Barcelona (Fig. 3, and see Supplementary Material); this is a tropical species and it is unlikely that it could survive for extended periods outdoors in a Mediterranean climate.

DISCUSSION

Overall our results showed that the coastal regions of Catalonia are highly vulnerable to the establishment of alien reptile populations, due to the mild climate and the importance of the pet trade. This is supported by the presence of several alien turtles, but also by other reptiles, such as monitor lizards (Soler & Martínez-Silvestre, 2013) and snakes (*Pantherophis guttatus* in Girona and Barcelona; D. Escoriza & G. Pascual, unpublished data). These alien turtles presumably have their origin in the pet trade because



Figure 4. Detail of diagnostic traits of some species of turtles with a problematic identification. Left column: head shape; Middle column: bridges; Right column: plastron. Upper line: *P. rubriventris*; Middle line: *M. mutica*; Bottom line: senile individuals of *T. scripta* superficially similar to *T. decussata*.



Figure 5. Example of a senile individual of *T. scripta elegans* (right side) similar in appearance to *T. decussata*, to the left side a normal-coloured *T. s. elegans* for comparison

there are no turtle breeding farms in this region, unlike other countries (Shi & Parham, 2001). These animals are usually isolated specimens and may have been released by their owners or otherwise have escaped captivity.

In other regions of the world, such as Florida, similar factors have favoured the establishment of numerous alien species with negative effects on native fauna (Dove et al., 2011). In our study we have not evaluated the effect of these species on native fauna, but these could be: (i) competition with native turtle species, because they have a similar trophic range and thermoregulation requirements (Pérez-Santigosa et al., 2011); (ii) hybridisation between congeneric species, e.g. *M. sinensis* and *M. mutica* with the native species *M.*

leprosa, as has been observed in other contact areas of the world, involving introduced *M. mutica* and the native *M. japonica* (Suzuki et al., 2013); (iii) predation on native aquatic fauna (Polo-Cavia et al., 2010), including vulnerable species of amphibians such as *Triturus marmoratus* or *Pelobates cultripedis*; and (iv) the transmission pathogens (Meyer et al., 2015).

Previous publications (e.g. Filella et al., 1999; Martínez-Silvestre et al., 2010) also reported the presence of the Cuban Slider (*Trachemys decussata*) in the study region. However, we did not find this species, but we found senile specimens of *T. scripta* with a similar external appearance (Fig. 4 and Fig. 5). However, these senile *T. scripta* individuals always retained a faded plastral spotting (Fig. 4), differing from that expected in *T. decussata* (an almost imperceptible spotting; Bonin et al., 1996). Therefore, we consider the presence of *T. decussata* in Catalonia at least doubtful, and that previous records could be assigned to senile *T. scripta*. The fact that all cited *T. decussata* were full-grown specimens also supported this statement. However, genetic analyses will be required to state with certainty the absence of *T. decussata* in the region, because there is the possibility of hybridisation with *T. scripta* (Parry, 2009).

We consider that it would be advisable to limit the trade of these invasive species, as was suggested by Maceda-Veiga et al. (2019). However, following the initial ban on the trade in one species (*T. scripta*) other species have filled the gap in the market with the result that they have been released (i.e. *Graptemys pseudogeographica*, *Mauremys sinensis*, *Pseudemys concinna* and *P. nelsoni*). For this reason we believe that the application of more efficient bans and regulations on the pet trade are necessary in order to end further turtle releases in urban ponds; furthermore naturalised individuals need to be removed. Maceda-Veiga et al. (2019) concluded that the release rates of invasive species have remained unchanged since the 2011 ban on their trade. However, the time period analysed in their study starts only after the ban which is too short a period to allow any inference, specially taking into account the long lifespan of turtles. Given the current situation, further studies are needed to evaluate the effectiveness of restrictions on the pet trade.

ACKNOWLEDGEMENTS

The specimens captured were handled following current legislation (RD1628/2011 and RD630/2013). We thank all the people that helped providing records, especially to Carlos Alvarez-Cros (GRUP NATURA STERNA), Gerard Dalmau (Consorci de l'Estany) and Jordi Hernández (SoHeVa). Many of the photos in this paper are by the authors but we had the kind permission of others to use their photos as follows: O. Buera (3.12), I. Comas (3.9, 5), S. Garcia (3.8, 3.11) and L. Mestre (3.1 – 3.3, 3.10). We thank Rick Hodges for his help in editing the English. We also thank several European LIFE projects which provided some of the observations included in this note: LIFE Estany (LIFE03NAT/E/00067), LIFE Emyster (LIFE04NAT/ES/000059), LIFE ProjecteEstany (LIFE08NAT/ES/000078), LIFE Riparia Ter (LIFE08NAT/E/000072) and LIFE Potamo Fauna (LIFE12NAT/ES/001091). Finally, we are indebted to Parc Natural de Collserola, Àrea Metropolitana

de Barcelona and to the city councils of Barcelona, Sant Cugat del Vallès, Sant Quirze del Vallès, Sitges and Viladecans.

REFERENCES

- Arribas, O. (2017). *Pseudemys rubriventris* (Le Conté, 1830) en un parque urbano de Barcelona. Primera cita en la península Ibérica. *Butlletí de la Societat Catalana d'Herpetologia* 24: 33-35.
- Bonin, F., Devaux, B. & Dupré, A. (1996). *Toutes les tortues du monde*. Paris: Delachaux et Niestlé, 416 pp.
- Clavero, M. & García-Berthou, E. (2006). Homogenization dynamics and introduction routes of invasive freshwater fish in the Iberian Peninsula. *Ecological Application* 16: 2313-2324.
- Conant, R. & Collins, J.T. (1998). *A Field Guide to Reptiles & Amphibians: Eastern and Central North America* (Vol. 12). Boston: Houghton Mifflin Harcourt, 493 pp.
- Couturier, T., Besnard, A., Bertolero, A., Bosc, V., Astruc, G. & Cheylan, M. (2014). Factors determining the abundance and occurrence of Hermann's tortoise *Testudo hermanni* in France and Spain: fire regime and landscape changes as the main drivers. *Biological Conservation* 170: 177-187.
- Dove, C.J., Snow, R.W., Rochford, M.R. & Mazzotti, F.J. (2011). Birds consumed by the invasive Burmese python (*Python molurus bivittatus*) in Everglades National Park, Florida, USA. *The Wilson Journal of Ornithology* 123: 126-131.
- Ernst, C.H. & Lovich, J.E. (2009). *Turtles of the United States and Canada*. Baltimore: Johns Hopkins University Press, 840 pp.
- Escoriza, D. (2018). Patterns of occurrence of semi-aquatic reptiles in highly invaded Mediterranean rivers. *NeoBiota*, 38: 23-35.
- Escoriza, D. & Boix, D. (2012). Assessing the potential impact of an invasive species on a Mediterranean amphibian assemblage: a morphological and ecological approach. *Hydrobiologia* 680: 233-245.
- Escoriza, D., Franch, M., Ramos, S., Sunyer-Sala, P. & Boix, D. (2019). Demographics and Survivorship in the European Pond Turtle *Emys orbicularis*: a 31-Year Study. *Herpetological Conservation & Biology* (in press).
- Filella, E., Rivera, X., Arribas, O. & Melero, J.A. (1999). Estatus i dispersió de *Trachemys scripta elegans* a Catalunya (Nord-est de la Península Ibèrica). *Butlletí de la Societat Catalana d'Herpetologia* 14: 30-36.
- García-Berthou, E., Boix, D. & Clavero, M. (2007). Non-indigenous animal species naturalized in Iberian inland waters. In *Freshwater Bioinvaders: Profiles, Distribution, and Threats*, pp. 123-140, Gherardi, F. (Ed). Dordrecht, Springer.
- Llorente, G., Montori, A., Santos, X. & Carretero, M. (1995). *Atlas dels Amfibis i Rèptils de Catalunya i Andorra*. Figueres: El Brau, 191 pp.
- Maceda-Veiga, A., Escribano-Alacid, J., Martínez-Silvestre, A., Verdaguer, I. & Mac, R. (2019). What's next? The release of exotic pets continues virtually unabated 7 years after enforcement of new legislation for managing invasive species. *Biological Invasions* 21: 2933-2947.
- Martínez-Silvestre, A., Soler, M., Saez, A. & Lopez, F. (2010). Nuevos datos de la interferencia de *Trachemys scripta* en ecosistemas mediterráneos en Cataluña (España). *XI Congreso Luso-Espanhol de Herpetologia; Anfíbios y Reptiles ante el Cambio Global* (77-78 pp), Sevilla, España.
- Martínez-Silvestre, A. & Cano, J.A. (2015). Tortuga mordedora (*Chelydra serpentina*) en Cataluña (NE de la Península Ibérica): nuevas citas y consideraciones sobre su riesgo invasor. *Boletín de la Asociación Herpetológica Española* 26: 91-93.
- Meyer, L., Du-Preez, L., Bonneau, E., Héritier, L., Franch, M., Valdeón, A., Sadaoui, A., Kechemir-Isaad, N., Palacios, C. & Verneau, O. (2015). Parasite host-switching from the invasive American red-eared slider, *Trachemys scripta*, to the native Mediterranean pond turtle, *Mauremys leprosa*, in natural environments. *Aquatic Invasions* 10: 79-91.
- Parry, B. (2009). The Red-eared Slider (*Trachemys scripta*) and hickatee (*Trachemys decussata*) on Grand Cayman. *Testudo* 7: 25-37.
- Pérez-Santigosa, N., Hidalgo-Vila, J., Florencio, M. & Díaz-Paniagua, C. (2011). Does the exotic invader turtle, *Trachemys scripta elegans*, compete for food with coexisting native turtles? *Amphibia-Reptilia* 32: 167-175.
- Polo-Cavia, N., Gonzalo, A., López, P. & Martín, J. (2010). Predator recognition of native but not invasive turtle predators by naïve anuran tadpoles. *Animal Behaviour* 80: 461-466.
- Pleguezuelos, J.M., Márquez, R. & Lizana, M. (2002). *Atlas y libro rojo de los anfibios y reptiles de España*. Madrid, Dirección General de Conservación de la Naturaleza-Asociación Herpetológica Española (2ª Ed.). 587 pp.
- Salvador, A. (2014). *Reptiles*: 2ª edición. Madrid: Museo Nacional de Ciencias Naturales-CSIC, 1372 pp.
- Seidel, M., & Ernst, C. (2017). A Systematic Review of the Turtle Family Emydidae. *Vertebrate Zoology* 67 (1): 1-122.
- Shi, H., & Parham, J.F. (2001). Preliminary Observations of a large turtle farm in Hainan Province, People's Republic of China. *Turtle and Tortoise Newsletter* 3: 4-6.
- Soler, J., Martínez-Silvestre, A., Budó, J., Capalleras, X., & Juárez, J.L. (2010). Análisis de la presencia de tortugas terrestres alóctonas autóctonas asilvestradas en Cataluña (NE España). *Boletín de la Asociación Herpetológica Española* 21: 63-68.
- Soler, J. & Martínez-Silvestre, A. (2013). Feral monitor lizards (*Varanus* sp.) in Catalonia, Spain: An increasing phenomenon. *Biawak* 7: 21-24.
- Suzuki, D., Yabe, T. & Hikida, T. (2013). Hybridization between *Mauremys japonica* and *Mauremys reevesii* inferred by nuclear and mitochondrial DNA analyses. *Journal of Herpetology* 48: 445-454.
- Tompkins, D.M., White, A.R. & Boots, M. (2003). Ecological replacement of native red squirrels by invasive greys driven by disease. *Ecology Letters* 6: 189-196.
- Türkozan, O., Özdemir, A. & Kiremit, F. (2008). International Testudo trade. *Chelonian Conservation and Biology* 7: 269-274.
- Uetz, P., Freed, P. & Hošek, J. (2019). The Reptile Database. <http://www.reptile-database.org>.

Accepted: 31 October 2019

Please note that the Supplementary Material for this article is available online via the Herpetological Bulletin website: <https://thebhs.org/publications/the-herpetological-bulletin/issue-number-151-spring-2020>