ABSTRACT

The trade of freshwater turtles as pets and their eventual release or escape has led to new naturalized alien species that eventually form invasive populations in aquatic ecosystems. The importation of alien \textit{Mauremys} spp. species implies a new threat to the conservation of aquatic ecosystems, due to their ability to hybridise with the native species \textit{Mauremys leprosa}. In this work, 16 new records of naturalised specimens of the Asian turtles \textit{Mauremys reevesii} and \textit{Mauremys sinensis} in Andalusia (southern Spain) are documented. Most of them (13) were found in artificial aquatic environments associated with urban areas, although the rest were found in protected natural areas sharing the habitat with natural populations of \textit{M. leprosa}. These new records recreate the pattern of sale-release-naturalization-invasion that has already occurred with other alien turtle species. The number of alien \textit{Mauremys} specimens imported into Spain (more than 100,000 since 2006) suggests that the current number of naturalised specimens could be much higher than reported in publications.

Keywords: pet trade; turtles; naturalisation; invasion; hybridisation.

RESUMEN

Nuevas citas de los galápagos chinos \textit{Mauremys reevesii} (Gray, 1831) y \textit{Mauremys sinensis} (Gray, 1834) (Testudines, Geoemydidae) en España

El comercio de quelonios acuáticos como animales de compañía y su eventual liberación o escape ha conllevado la detección de especies exóticas naturalizadas o formando poblaciones invasoras en ecosistemas acuáticos. La importación de \textit{Mauremys} spp. exóticos implica una nueva amenaza para la conservación de los ecosistemas acuáticos, debido a su capacidad de hibridarse con la especie nativa \textit{Mauremys leprosa}. En este trabajo se documentan 16 nuevos registros de ejemplares asilvestrados de los galápagos asiáticos \textit{Mauremys reevesii} y \textit{Mauremys sinensis} en Andalucía (sur de España). La mayor parte de ellos (13) corresponden a ambientes acuáticos artificiales asociados a áreas urbanas y el resto se encontraron en espacios naturales protegidos con poblaciones naturales de \textit{M. leprosa}. Estas nuevas citas ponen de manifiesto que los nuevos taxones comercializados reproducen el patrón de venta-liberación-naturalización-invasión que ya acaeció con otras especies exóticas de galápagos. El número de ejemplares de \textit{Mauremys} exóticos importados en España (más de 100,000 desde 2006) sugiere que el número real de ejemplares asilvestrados podría ser bastante mayor al documentado en los trabajos publicados.

Palabras clave: comercio de mascotas; tortugas; naturalización; invasión; hibridación.
The pet trade is one of the main introduction pathways of invasive alien species. Exotic freshwater turtles are a worldwide paradigm of invasion from imported pets that are later abandoned into aquatic ecosystems by their owners or escape confinement (Lockwood et al., 2019). In Spain, alien turtles outcompete the native endangered terrapins: the European pond turtle, *Emys orbicularis* (Linnaeus, 1758), and the Spanish terrapin, *Mauremys leprosa* (Schweigger, 1812)) (Polo-Cavia et al., 2010a, 2010b, 2011). The trade of red-eared slider *Trachemys scripta* subsp. *elegans* (Wied, 1838) was banned in Europe in 1997 following salmonellosis outbreaks in children and biodiversity concerns (Woodward et al., 1997). However, other freshwater turtle species such as *Chrysemys picta* (Schneider, 1783), *Graptemys* spp., *Macrochelys* temminckii Troost, 1835, alien *Mauremys* spp., *Pelomedusa subrufa* (Bonnaterre, 1789), *Pelusios* spp., or even a subspecies of the banned taxon (*Trachemys scripta* subsp. *scripta* (Thunberg, 1792)) have been imported into Spain (Cites Trade Database, 2020) although they may also be reservoirs of pathogens and invade aquatic ecosystems (e.g., Martinez-Silvestre et al., 2015; Sancho et al., 2015; Back et al., 2016). In 2013, the Spanish legislation (Royal Decree 613/2013) banned the trade of *Trachemys scripta* (Thunberg in Schoepff, 1792), *Chrysemys picta* and *Pseudemys peninsularis* Carr, 1938. Three years later, the list of invasive alien species of Union concern also banned *Trachemys scripta* according to the Commission implementing regulation 2016/1141. Despite these regulation advances, many unbanned pond turtle species have been imported in the last two decades, including some dangerous species such as the snapping turtle *Chelydra serpentina* (Linnaeus, 1758) (Cites Trade Database, 2020). To date, up to 21 freshwater alien chelonian taxa have been reported in Spanish natural, seminatural or artificial wetlands: *Apalone ferox* (Schneider, 1783), *Chrysemys picta*, *Chelydra serpentina*, *Graptemys ouachitensis* (Cagle, 1953), *Graptemys pseudogeographica* (Gray, 1831), *Macrochelys temminckii*, *Mauremys mutica* (Cantor, 1842), *Mauremys reevesii* (Gray, 1831), *Mauremys sinensis* (Gray, 1834), *Pseudemys concinna* (Le Conte, 1830), *Pseudemys nelsoni* Carr, 1938, *Pseudemys rubriventris* (Le Conte, 1830), *Pelodiscus sinensis* (Wiegmann, 1835), *Pelomedusa subrufa*, *Trachemys decussata* (Gray, 1831), *Trachemys emolli* (Legler, 1990), *Trachemys ornata* (Gray, 1831), *Trachemys scripta* subsp. *elegans*, *Trachemys scripta* subsp. *scripta*, *Trachemys scripta elegans* x *Trachemys scripta scripta*, and *Trachemys scripta* subsp. *troostii* (Hollbrook, 1836) (Mateo et al., 2011; Balmori, 2014 and references therein; Campos-Such et al., 2015; Cruz et al., 2015; Martinez-Silvestre et al., 2015; Poch et al., 2020).

The case of alien taxa of the genus *Mauremys* is of particular concern due to their ability to hybridise with the native species *Mauremys leprosa* (Nickl, 2015; Sancho et al., 2020). Between 2006 and 2019, 55,825 live individuals of Reeves’ pond turtle *Mauremys reevesii* and 45,320 live individuals of the Chinese stripe-necked turtle *Mauremys sinensis* have been imported into Spain, mainly from China, Hong Kong, Taiwan and Japan (Cites Trade Database, 2020). Although these species have been imported more recently and in much smaller quantities than *Trachemys scripta elegans* (up to 900,068 individuals until the year 2000; Cites Trade Database, 2020), their eventual release into the natural environment represents a conservation concern, particularly for the native *Mauremys leprosa*. Until now, the presence of naturalised specimens of *M. sinensis* was documented in the regions of Valencia and Catalonia (Campos-Such et al., 2015; Martinez-Silvestre et al., 2015, 2019), whereas *M. reevesii* was cited in Galicia (Ayres, 2016) and Catalonia (Poch et al., 2020).

Considering that early detection is an essential tool for efficient management, new citations of *Mauremys reevesii* and *Mauremys sinensis* from southern Spain were compiled from different sources (mainly naturalists, amateurs or nature managers) between 2009 and 2020. All records were georeferenced, using the UTM projection and the ETRS1989 reference system, in extended zone 30, in accordance with European standards. Only those citations that could be validated through photographs or captured specimens were included. In total, 15 new validated records were collected: seven records corresponded to *M. reevesii* and eight records to *M. sinensis* (Table 1; Fig. 1).

All *M. reevesii* records showed the characteristic yellowish striping and blotching extending down the neck from the snout, whereas *M. sinensis* showed the characteristic parallel, narrow yellow stripes on their heads, necks and parts of their legs (Fig. 1).

In sum, the new records included five of the eight provinces of Andalusia. Most of them (12/15) were found in artificial lakes, while the rest were found in protected areas (the ‘Arroyo Negro’ and ‘Laguna del Portil’ natural reserves), sharing the habitat with natural populations of *M. leprosa*. All locations were adjacent to urban centres, which may favour the reception of abandoned pets. Both species constitute new records to Andalusia.

The results suggest that the introduction of *Mauremys reevesii* and *M. sinensis* is not an anecdotal fact, but rather reproduces the ‘sale-release-naturalisation-invasion’ process that has already occurred with other exotic freshwater turtles marketed as pets and other regions (Sancho & Lacomba, 2016; Poch et al., 2020). There are several limitations for a new record to be reported: (i) the taxon must ‘cross’ a person’s view or be captured, and detectability decreases at low population size (Metha et al., 2007). In fact, the *M. sinensis* specimen found at ‘Laguna del Portil’ Natural Reserve was captured after six days of an alien turtle control campaign that used six baited fyke...
documented in publications (García-de-Lomas et al., 2016; Vall-llosera & Cassey, 2017). Therefore, further surveillance of aquatic ecosystems is recommended to detect the presence of alien *Mauremys* species early and to implement rapid response actions.

Moreover, the increasing records of alien *Mauremys* spp. in Spain provides further evidence that all the turtle

![Image of turtle specimens](image-url)

**Fig. 1.—** Specimens of *Mauremys reevesii* observed in Málaga (left) and *Mauremys sinensis* found in Laguna del Portil Natural Reserve, Huelva (right). Photos by Juan Pablo González de la Vega©.

**Fig. 1.—** Ejemplares de *Mauremys reevesii* observados en Málaga (izquierda) y *Mauremys sinensis* encontrado en la Reserva Natural Laguna del Portil, Huelva (derecha). Fotos de Juan Pablo González de la Vega©.

| Species       | Date       | UTM X   | UTM Y   | Altitude (m) | Locality, Province                          | Habitat type | Source (observer) |
|---------------|------------|---------|---------|--------------|---------------------------------------------|--------------|------------------|
| *Mauremys reevesii* | 08/06/2020 | 290484  | 4008421 | 2            | Arroyo del Portil Natural Microreserve, La Línea de la Concepción, Cádiz | Natural      | Cerpa-González, R.M. |
| *Mauremys reevesii* | 11/03/2020 | 368539  | 4064327 | 45           | Botanic Garden, University of Málaga        | Artificial   | Fernández-Meléndez, E.  |
| *Mauremys reevesii* | 05/05/2018 | 363185  | 4050784 | 20           | ‘La Paloma’ garden, Benalmádena, Málaga     | Artificial   | González-de-la-Vega, J.P. |
| *Mauremys reevesii* | 12/11/2019 | 373292  | 4064806 | 13           | Garden beside the Cathedral, Málaga        | Artificial   | González-de-la-Vega, J.P. |
| *Mauremys reevesii* | 30/09/2019 | 443450  | 4105640 | 779          | ‘Parque de la Estación’, Otriza, Granada    | Artificial   | Marín-Escribano, J.M.   |
| *Mauremys reevesii* | 18/08/2017 | 445899  | 4113838 | 660          | ‘Parque Federico García Lorca’, Granada    | Artificial   | Fernández-Cardenete, J.R. |
| *Mauremys reevesii* | 07/05/2017 | 363672  | 4052553 | 96           | Garden at ‘Altos del Olivar’ urbanisation, Torremolinos, Málaga | Artificial   | González-de-la-Vega, J.P. |
| *Mauremys sinensis* | 20/06/2019 | 234901  | 4145340 | 5            | ‘Parque del Alamillo’, Sevilla              | Artificial   | Verdejo-Díaz, P.A.    |
| *Mauremys sinensis* | 01/10/2020 | 1411119 | 4126066 | 6            | ‘Laguna del Portil’ Natural Reserve, Punta Umbría, Huelva | Natural      | Rodríguez-Andrés, J.L. |
| *Mauremys sinensis* | 30/10/2020 | 445899  | 4113838 | 660          | ‘Parque Federico García Lorca’, Granada    | Artificial   | Luna-Fernández, A.    |
| *Mauremys sinensis* | 05/06/2019 | 151751  | 4124665 | 15           | Botanic Garden ‘José Celestino Mutsa’, Palos de la Frontera, Huelva | Artificial   | Bonoño-Quiones, L.     |
| *Mauremys sinensis* | 22/02/2009 | 141180  | 4125741 | 5            | Open land beside ‘Laguna del Portil’ Natural Reserve, Punta Umbría, Huelva | Natural      | González-de-la-Vega, J.P. |
| *Mauremys sinensis* | 19/06/2016 | 363185  | 4050784 | 20           | ‘La Paloma’ garden, Benalmádena, Málaga     | Artificial   | González-de-la-Vega, J.P. |
| *Mauremys sinensis* | 11/06/2019 | 237678  | 4144578 | 8            | ‘Miraflores’ garden, Sevilla               | Artificial   | Verdejo-Díaz, P.A.    |
| *Mauremys sinensis* | 05/10/2017 | 308951  | 4074854 | 602          | Garden in Arriate, Málaga                  | Artificial   | Melgar-Gómez, R.     |
taxa marketed as pets are prone to be released and become a conservation threat. This fact suggests that banning particular species in the form of ‘blacklists’, far from solving the problem, may favour the trade of unbanned species (García-de-Lomas & Vilà, 2015). Thus, banning the movement and sale of all freshwater alien turtles apart from specifically permitted non-invasive, non-harmful species (in the form of a ‘white’ list) could help reverse the current trend of naturalisation and invasion.

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References

Ayres, C., 2016. Mauremys reevesi (Gray, 1831), familia Geoemydidae, en liberdad no Noroeste de España: o primeiro de moitos en Europa? Botaña, 14: 58-59. Available from https://gslnh.org/wp-content/uploads/2018/06/Ayres-Fernandez_Mauremys-reevesi_Gray1831_familia_Geoemydidae_liberdade_Noroeste_Espanha_Botaña_2016.pdf [Accessed 22 Dec. 2020].

Back, D.S., Shin, G.-W., Wendt, M. & Heo, G.-J., 2016. Prevalence of Salmonella spp. in pet turtles and their environment. Laboratory Animal Research, 32(3): 166-170. https://doi.org/10.5625/lar.2016.32.3.166

Balmori, A., 2014. Utilidad de la legislación sobre especies invasoras para la conservación de las especies de galápagos ibéricos. Boletín de la Asociación Herpetológica Española, 25: 68-74.

Campos-Such, D., Miñarro, M. & Valls, L., 2015. Localización de un ejemplar asilvestrado de Mauremys marginata en el Parque Natural de las Lagunas de Ruidera (Ciudad Real). Boletín de la Asociación Herpetológica Española, 26(1): 89-91.

CITES Trade Database. 2020. Available from https://trade.cites.org/es/cites_trade/ [Accessed 22 Dec. 2020].

Cruz, D., Delgado, P., López, V. & Montero, J., 2015. Presencia de Apalone ferox en el Parque Natural de las Lagunas de Ruidera (Ciudad Real). Boletín de la Asociación Herpetológica Española, 26(1): 89-91.

García-de-Lomas, J., Dana, E.D., Chaves, J., Ramírez, J.M. & Lineros, A., 2016. Entre pitones y pantaneras: encuentros con animales exóticos peligrosos en Andalucía. El Corzo, 4: 62-71. Available from http://sociedadadiganitanhistorianatural.com/wp-content/uploads/2016/02/09_ElCorzo4_2016_encuentros_especies_peligrosas.pdf [Accessed 20 Dec. 2020].

García-de-Lomas, J. & Vilà M., 2015. Lists of harmful alien organisms: Are the national regulations adapted to the global world? Biological Invasions, 17: 3081-3091. https://doi.org/10.1007/s10530-015-0939-7

Lockwood J.L., Welbourne D.J., Romagosa C.M., Cassey P., Mandrak N.E., Strecker A., Leung, B., Stringham, O.C., Udell, B., Episcopio-Sturgeon, D.J., Trusty, M.F., Sinclair, J., Springborn, M.R., Pienaar, E.F., Rhyne, A.L. & Keller, R., 2019. When pets become pests: the role of the exotic pet trade in producing invasive vertebrate animals. Frontiers in Ecology and the Environment, 17(6): 323-330. https://doi.org/10.1002/fee.2059

Martínez-Silvestre, A., Guinea, D., Ferrer, D. & Pantchev, N. 2015. Parasitic enteritis associated with the camallanid nematode Serpinema microcephalus in wild invasive turtles (Trachemys, Pseudemys, Graptemys and Ocadia) in Spain. Journal of Herpetological Medicine and Surgery, 25: 48-52. https://doi.org/10.5818/1529-9651-25.1.48

Martínez-Silvestre, A., Soler, J. & Cano, J.M., 2019. Adaptación y reproducción de Mauremys sinensis a las condiciones naturales del nordeste de la península ibérica. Boletín de la Asociación Herpetológica Española, 30: 75-78.

Mateo, J.A., Ayres, C. & López-Jurado, L. F. 2011. Los anfibios y reptiles naturalizados en España: Historia y evolución de una problemática reciente. Boletín de la Asociación Herpetológica Española, 22: 2-42.

Metha, S.V., Haight, R.G., Homans, F.R., Polasky, S. & Venette, R.C., 2007. Optimal detection and control strategies for invasive species management. Ecological Economics, 61: 237-245. https://doi.org/10.1016/j.ecolecon.2006.10.024

Nickl, S., 2015. Kann denn liebe sünde sein? Eine randnotiz zu hybriden aus Mauremys leprosa und Mauremys reevesi. Marginata, 44: 60-64.

Poch, S., Sunyer, P., Pascual, G., Boix, D., Campos, M., Cruset, E. et al., 2020. Alien chelonians in north-eastern Spain: new distributional data. The Herpetological Bulletin, 151: 1-5. https://doi.org/10.33256/hb151.15

Polo-Cavia, N., Gonzalo, A., López, P. & Martín J., 2010a. Predator recognition of native but not invasive turtle predators by naïve anuran tadpoles. Animal Behaviour, 80(3): 461-466. https://doi.org/10.1016/j.anbehav.2010.06.004

Polo-Cavia, N., López, P. & Martín J., 2010b. Competitive interactions during basking between native and invasive freshwater turtle species. Biological Invasions, 12(7): 2141-2152. https://doi.org/10.1007/s10530-009-9615-0

Polo-Cavia, N., López, P. & Martín J., 2011. Aggressive interactions during feeding between native and invasive freshwater turtles. Biological Invasions, 13(6): 1387-1396. https://doi.org/10.1007/s10530-010-9897-2

Sancho, V. & Lacomba, J.I., 2016. Expansion of Trachemys scripta in the Valencian Community (Eastern Spain). In: Proceedings of the International Symposium on Freshwater Turtles Conservation. Águas e Parque Biológico de Gaia. Vila Nova de Gaia: 41-49.

Sancho, V., Lacomba, J.I., Bataller, J.V. & Pradillo, A., 2015. Manual para el Control y Erradicación de Galápagos Invasores. Colección Manuales Técnicos de Biodiversidad, 6. Conselleria d’Agricultura, Medi Ambient, Canvi Climàtic i Desenvolupament Rural. Generalitat Valenciana, Valencia. Available from https://agroambient.gva.es/documents/91061501/161549814/Manual+para+el+Control+y+Erradicaci%C3%B3n+de+Gala+pagos+Invasores.pdf
Vall-llosera, M. & Cassey, P., 2017. Leaky doors: private captivity as a prominent source of bird introductions in Australia. *PLoS ONE*, 12: e0172851. https://doi.org/10.1371/journal.pone.0172851

Woodward, D.L., Khakhria, R. & Johnson, W.M., 1997. Human salmonellosis associated with exotic pets. *Journal of Clinical Microbiology*, 35: 2786-2790. https://doi.org/10.1128/jcm.35.11.2786-2790.1997