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DATA PAPER

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Distribution of alien tetrapods in the Iberian Peninsula

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Abstract

We present a dataset that assembles occurrence records of alien tetrapods (amphibians, reptiles, birds and mammals) in the Iberian Peninsula, a coherent biogeographically unit where introductions of alien species have occurred for millennia. These data have important potential applications for ecological research and management, including the assessment of invasion risks, formulation of preventive and management plans, and research at the biological community level on alien species. This dataset summarizes inventories and data sources on the taxonomy and distribution of alien tetrapods in the Iberia Peninsula, comprising known locations from published literature, expert knowledge and citizen science platforms. An expert-based assessment process allowed the identification of unreliable records (misclassification or natural dispersion from native range), and the classification of species according to their status of reproduction in the wild. Distributional data was harmonized into a common area unit, the 10 × 10 km Universal Transverse Mercator (UTM) system (n = 6,152 cells). The year of observation and/or year of publication were also assigned to the records. In total, we assembled 35,940 unique distribution records (UTM × species × Year) for 253 species (6 amphibians, 16 reptiles, 218 birds and 13 mammals), spanning between 1912 and 2020. The species with highest number of distribution records were the Mediterranean painted frog *Discoglossus pictus* (n = 59 UTM), the pond slider *Trachemys scripta* (n = 471), the common waxbill *Estrilda astrild* (n = 1,275) and the house mouse *Mus musculus* (n = 4,043), for amphibians, reptiles, birds and mammals, respectively. Most alien species recorded are native to Africa (33%), followed by South America (21%), Asia (19%), North America (12%) and Oceania (10%). Thirty-six species are classified by IUCN as threatened in their native range, namely 2 Critically Endangered (CR), 6 Endangered (EN), 8 Vulnerable (VU), and 20 species Near Threatened (NT). Species maps are provided in DataSet1, as well R code and GIS layers to update them as new records are obtained.

Keywords

Alien terrestrial vertebrates, biological invasions, Iberian Peninsula, invasive species, Portugal, Spain

Introduction

The human-mediated introduction of species into regions outside their native range is an important component of global change. Alien species (*sensu* Essl et al. 2018) are responsible for the decline and extinction of native species, economic losses and human health problems (Clavero and García-Berthou 2005; Tatem et al. 2006; Hulme 2009; Simberloff et al. 2013) and are leading to irreversible changes to the diversity and distribution of life on Earth (Simberloff et al. 2013; Capinha et al. 2015). Alien species can impact receiving ecosystems, even if simply through competition with native species for space, food, water or other resources. Although impacts perceived as 'significant' are generally recorded for only a subset of alien species, i.e. the 'alien invasive species' (*sensu* IUCN 2000), many ongoing invasions may have simply not yet spread to the point when impacts become noticeable. Furthermore, several invasions may have already been set in motion, leading to impacts in the near future (Essl et al. 2011). Some alien species may be currently in a lag-phase, during which little or no increase in distributional ranges is observed; that may be followed by an increase-phase in which their occurrence and invasiveness rises rapidly (Aikio et al. 2010; Essl et al. 2011; Russell and Blackburn

2017). Hence, data on alien species occurrence is crucial and a first step to understand the main drivers shaping their distribution (Abellán et al. 2017; Ascensão et al. 2020) and delineate effective management actions and policies accordingly (Abellán et al. 2017; Hattab et al. 2017; Carboneras et al. 2018; Ascensão et al. 2020).

In natural environments, alien tetrapods (amphibians, reptiles, birds and mammals) can compete with, and predate, native species. The American mink (*Neovison vison*), for example, led to significant population declines of ground nesting birds (e.g. the black-headed gull *Chroicocephalus ridibundus* or the common tern *Sterna hirundo*), and small mammals (e.g. the European water vole *Arvicola amphibius* and the Pyrenean desman *Galemys pyrenaicus*) in its introduced range (Craik 1997; Aars et al. 2001). Also, the rose-ringed Parakeet (*Psittacula krameri*), invasive in Iberia, is highly aggressive toward the tree-dwelling greater noctule bat (*Nyctalus lasiopterus*) when trying to occupy their tree cavities. Rose-ringed parakeet aggressions often result in noctule death, causing population declines and disruption of the complex social behavior of this bat species (Hernández-Brito et al. 2018). Likewise, the pond slider (*Trachemys scripta*) feeds on several native species of plants and animals, and it potentially competes with native turtles, such as the endangered European pond turtle (*Emys orbicularis*), for food, basking and nesting sites (Cadi and Joly 2003, 2004; Balzani et al. 2016). On the other hand, the economic impacts of tetrapods can be striking. For example, in Italy the coypu (*Myocastor coypus*) caused over 11 Mio € in damages during 1995–2000 and similar developments have been suggested for Spain (Panzacchi et al. 2007). Likewise, the monk parakeet (*Myiopsitta monachus*) or the rose-ringed Parakeet are considered important avian pests (Kumschick and Nentwig 2010; Senar et al. 2016; Reyns et al. 2018).

Here, we provide a first compilation of the distribution of the alien tetrapods in Iberian Peninsula. This region integrates the Mediterranean biodiversity hotspot, harboring about half of the European plant and terrestrial vertebrate species (Myers et al. 2000). It is also a region where many alien species are becoming common and spreading, but no cross-taxonomic assessment on distribution patterns has been performed to date, except for birds (Abellán et al. 2016, 2017; Ascensão et al. 2020). The dataset here described contains information on the known occurrences of alien amphibians, reptiles, birds and mammals in this region. We considered all known species with individuals occurring freely in cities and in the countryside (not in captivity), but we discarded domestic species. For each species, we have also included information on current status of establishment in the Iberian Peninsula, classifying each species as 'established', 'not established', or 'uncertain'. The applications of these data range from supporting the development of measures for the prevention and management of biological invasions to undertaking species- and community-level ecological research. Specifically, the assembled data allows more detailed research on the distribution of single alien species and of the spatial patterns of richness and composition of alien species assemblages at the regional scale (Ascensão et al. 2020). These potential applications are of specific relevance for a number of species currently being targeted by national and EU-level legislation.

Metadata

Data set descriptors

A. Data set identity

Registry of alien tetrapods (terrestrial and freshwater vertebrates) in the Iberian Peninsula.

B. Data set description

This dataset summarizes inventories and data sources on the distribution of alien tetrapods in the Iberian Peninsula, from 1912 onwards, comprising known locations from published literature, expert knowledge and citizen science platforms. An expert-based filtering process allowed the identification of unreliable records (e.g., misclassification or natural dispersion from native range). Distributional data was harmonized into a common area unit, the Universal Transverse Mercator (UTM) system (n = 6,152 10 × 10 km cells). The dataset consists of one file, containing a 15 × 159,677 matrix of values, including information on species, location, time, current establishment status and source. In total, we assembled 35,940 unique distribution records (UTM × species × Year) for 253 species (6 amphibians, 16 reptiles, 218 birds and 13 mammals) (Fig. 1), spanning between 1912 and 2020 (Fig. 2). Fifty-six species (22%) are known to re-

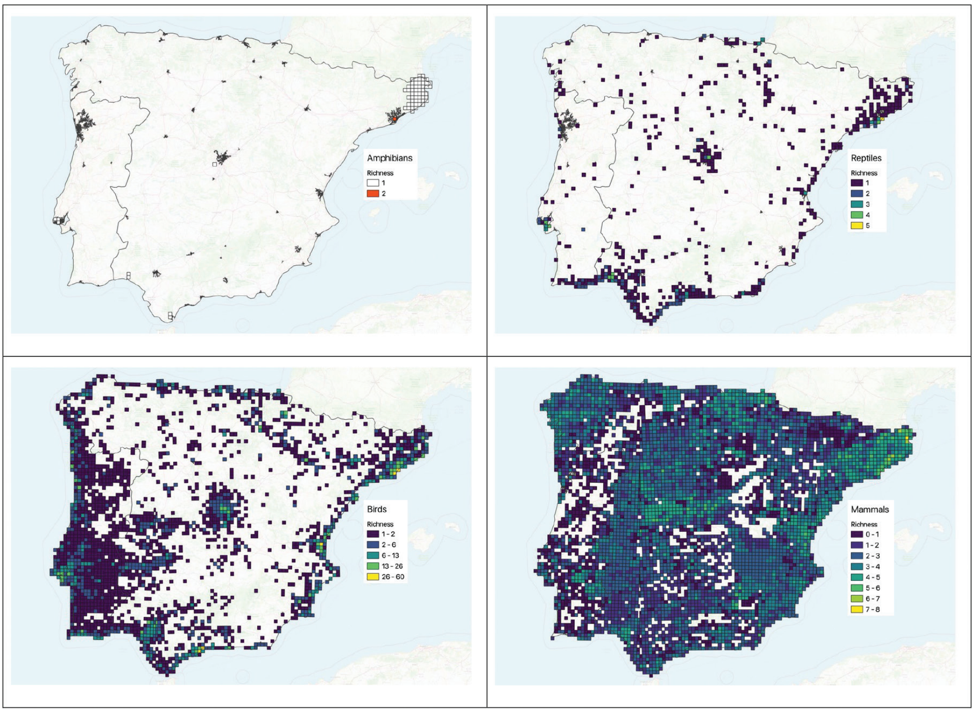

Figure 1. Richness of alien tetrapods in Iberian Peninsula, by taxonomic Class.

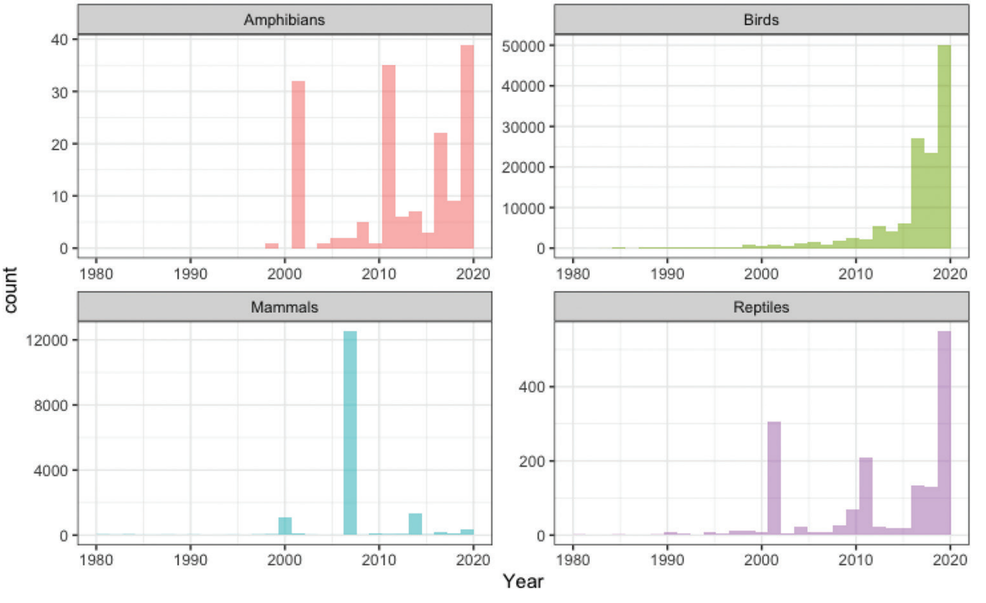

Figure 2. Yearly distribution of records on non-native tetrapods in the Iberian Peninsula. Year in x-axis refers to the most accurate timeframe information available and may indicate the time of publication (e.g., Spanish Atlas of Mammals in 2007), or the actual time of observation for the data (e.g., from citizen science platforms). Between 1912 and 1980 there are 138 records (<0.1% of total), not shown.

produce in the wild (established in Iberia), whereas for 98 species (39%) there is no evidence for being established, and for 99 species (39%) the establishment status is uncertain. The species with the highest number of distribution records were the Mediterranean painted frog *Discoglossus pictus* (n = 59 UTM), the pond slider *Trachemys scripta* (n = 471), the common waxbill *Estrilda astrild* (n = 1,275) and the house mouse *Mus musculus* (n = 4,043). Most alien species recorded are native to Africa (33%), followed by South America (21%), Asia (19%), North America (12%) and Oceania (10%). Thirty-six species are classified by IUCN as threatened in their native range, namely 2 Critically Endangered (CR), 6 Endangered (EN), 8 Vulnerable (VU), and 20 species Near Threatened (NT). The file is labelled as "Data_AscensãoEtAl_Neobiota.csv".

1. Principal investigators

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Research origin descriptors

A. Overall project description

1. Identity

This dataset assembles and harmonizes all known locations of alien terrestrial and freshwater vertebrates (tetrapods) in the Iberian Peninsula by UTM cell (ca. 10 × 10 km). The taxonomy and origin are also provided for each species.

2. Originators

The data was collected under the project "The role of transportation in Biological Invasions" funded by Infraestruturas de Portugal Biodiversity Chair (ref02035004). Methodology was developed by Fernando Ascensão and César Capinha. All authors participated in data collection and validation process.

3. Period of study

Data was collected from 01/01/2017 to 10/08/2020. Collected data included records from 1912 to 2020.

4. Objectives

The primary objective of the present work was to compile a registry of non-native vertebrates (tetrapods) present in the Iberian Peninsula. The applications of these data range from supporting the development of measures for the prevention and management of biological invasions to undertaking species- and community-level ecological research. Specifically, the assembled data allows more detailed research on the distribution of single alien species and of the spatial patterns of richness and composition of alien species assemblages at the regional scale. These potential applications are of specific relevance for a number of species currently being targeted by national and EU-level legislation.

5. Source of funding

Infraestruturas de Portugal Biodiversity Chair (ref02035004) funded the project "The role of transportation in Biological Invasions". F. Ascensão was also funded by Fundação para a Ciência e Tecnologia – grant SFRH/BPD/115968/2016.

Summary of "The role of transportation in Biological Invasions" project

The naturalization of non-native species is now one of the main mechanisms responsible for altering the biosphere, causing profound changes in the structure and functioning of ecosystems. Given the increasing mobility of people and goods, concomitant with the increase in road and rail networks, and consequent increase in the number of introductions (intentional or not) of non-native species in new locations, it is expected that these changes will continue worsening sharply in the future. The main objective of this project was to deepen the knowledge about the biogeographic patterns that are emerging as a result of this growing mix of species. Part of the data has been published in Ascensão et al. (2020).

B. "Specific" subproject description

1. Site description:

a. Site type

Data was collected for all of the Iberian Peninsula, namely continental areas of Portugal and Spain, together with Gibraltar (a British Overseas Territory located at the southern tip of the Iberian Peninsula).

b. Geography

Continental areas of Portugal and Spain, together with Gibraltar (a British Overseas Territory located at the southern tip of the Iberian Peninsula).

c. Habitat

The region includes terrestrial and freshwater habitats.

d. Geology, landform

The region includes various geological types, ranging from Ediacaran to the Quaternary.

e. Watersheds, hydrology

All river systems in the Iberian Peninsula.

f. Climate

Climatic conditions in the study area range from Mediterranean (most part) to Atlantic (northern region).

2. Experimental or sampling design

a. Design characteristics

Data was obtained following the framework depicted in Fig. 3, through extensive data source search, from scientific literature to online databases, museum collections and by requesting unpublished data to experts on alien species and from citizen science

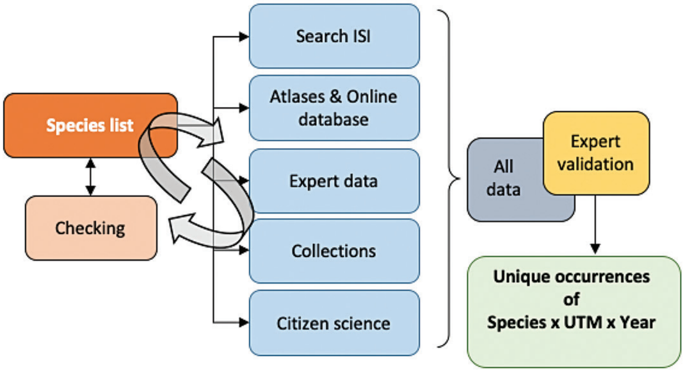

Figure 3. Framework of collection of occurrence records of alien tetrapod species in the Iberian Peninsula.

platforms. Data was then validated through an expert-based procedure to ensure the accuracy and validity of the occurrence records.

b. Data collection period, frequency, etc.

Basic data collection period was 01/01/2017 to 10/08/2020.

3. Research methods

The first step was to identify all tetrapod species occurring in the Iberian Peninsula. We first listed these species by searching in key publications, including national atlases from Portugal (Matias 2002; Equipa Atlas 2008; Loureiro et al. 2008; Catry et al. 2010; Bencatel et al. 2017) and Spain (Barbadillo et al. 1999; Pleguezuelos et al. 2002; Martí and del Moral 2003), and from the recent assessments dedicated to alien birds in the Iberian Peninsula by Abellán et al. (2016). The listing was updated whenever the indication of additional alien species was found during the occurrence data search. All names were standardized according to the IUCN (www.iucnredlist.org), but we retained the alternative names to perform subsequent data searches.

A collection of experts was gathered (all authors of this study) to discuss the cryptogenic status of some species. This resulted in a list of 406 species potentially occurring in the Iberian Peninsula. After debate among the authors, a few species listed as alien in some data sources were not considered because there was substantial uncertainty about their nativity in the region (Table 1).

Occurrence data was searched in multiple types of sources, including published literature (atlases, research articles, databases), from citizen science data portals and through requests of unpublished data to institutions and experts.

Published literature: The ISI Web of Science (https://apps.webofknowledge.com) was searched using the search term: “TS = ((*list of species names including alternative ones*

Table 1. Species for which there was debate among the authors about whether or not they should be considered native, and for which it was finally decided not to consider as such.

Species	Support
Edible frog	Highly difficult to distinguish from *Rana perezi*, requires genetic data.
Pelophylax kl. *Esculentus*	
Spur-thighed tortoise	Unclear origin (Graciá et al. 2013)
Testudo graeca	
False smooth Snake	Unclear origin (Loureiro et al. 2008)
Macroprotodon cucullatus	
Egyptian mongoose	Unclear origin (Gaubert et al. 2011)
Herpestes ichneumon	
European mink	Unclear origin (Clavero 2014; Maran et al. 2016)
Mustela lutreola	

separated by "OR") AND CU = (Portugal OR Spain)) AND DOCUMENT TYPES: (Article OR Book OR Book Chapter OR Data Paper OR Proceedings Paper OR Review)". The search was then refined by using the filters RESEARCH AREAS: (ZOOLOGY OR ENVIRONMENTAL SCIENCES ECOLOGY) AND WEB OF SCIENCE CATEGORIES: (ZOOLOGY OR ECOLOGY OR BIODIVERSITY CONSERVATION). The timespan was 2002 (inclusive) onward. We restricted the search to 2002 because previous records are expected to be compiled in the Atlases (see below). The searches were last updated on August 10th, 2020. This resulted in a collection of 767 references, of which 199 articles were identified from their abstracts as potentially containing useable location data. Finally, occurrences of alien species were retrieved from 65 publications (Table 2).

For Portugal, occurrence data further included information from atlases (Bencatel et al. 2017; Catry et al. 2010; Equipa Atlas 2008; Loureiro et al. 2008; Matias 2002); and for Spain information was also obtained from the online database 'Inventario Español de Especies Terrestres' (IEET 2014). This database compiles information from several sources, including atlases and other databases (Table 3). Additional information for Spain was obtained from Barbadillo et al. (1999), Martí and del Moral (2003) and Pleguezuelos et al. (2002).

Citizen science: We further collected information from four different citizen science platforms, including 'Biodiversity4all' (Biodiversity4All 2020), 'Proyecto Avis' (Varela et al. 2014; URL: proyectoavis.com), 'Colectivo Ornitologico Cigüeña Negra' (COCN; URL: http://bd.cocn.eu), eBird (eBird 2020; Sullivan et al. 2009), and iNaturalist (iNaturalist 2020). The records from Proyecto Avis, COCN and Biodiversity4all were provided directly by their administrators, P. Tiago and E. Casabella, in August 2020. The records from eBIRD were downloaded from its site (full dataset) in August 2020. iNaturalist, records were downloaded using the R packages 'rgbif' (Chamberlain et al. 2016) in R environment (R Core Team 2020) in August 2020.

Table 2. Studies from which locations of alien terrestrial vertebrates were retrieved.

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Table 3. Sources of 'Inventario Español de Especies Terrestres' (IEET 2014), and the number of records retrieved from each source. Base de Datos AHE – amphibian and reptile database of the Spanish Herpetological Association; PASER – Spanish Bird banding monitoring program; SACRE – Spanish Common Bird Sensus Program; SECEM – Spanish Society for the Conservation and Study of Mammals.

Source	Records
Base de Datos AHE (2011)	446
Pleguezuelos et al. (2002). Atlas y Libro Rojo de los Anfibios y Reptiles de España.	805
Madroño et al. (2004). Libro Rojo de las Aves de España.	660
PASER (2008)	4
PASER (2009)	3
PASER (2010)	1
PASER (2011)	4
SACRE (2008)	18
SACRE (2009)	13
SACRE (2010)	15
SACRE (2011)	40
Palomo (2007). Atlas y Libro Rojo de los Mamíferos Terrestres de España.	12,513
SECEM 2009–2013	3

Unpublished data: In addition to the data directly sourced from published literature and online platforms, unpublished occurrence data were obtained through contacts with multiple experts (co-authors).

Data treatment: We considered all records with geographic coordinates and/or Universal Transverse Mercator (UTM) 10 × 10 km identified. All records were standardized into individual 10 × 10 km cells of the Universal Transverse Mercator (UTM) grid system. All data records compiled had coordinates with low (<1 km) coordinate uncertainty.

Accuracy and validity of the occurrence records: The following procedures were carried out for the final version of the database to ensure the accuracy and validity of the occurrence records. For each species, we built a distribution map in the Iberian Peninsula, identifying the UTM cells. These maps were sent to the panel of experts who confronted the mapped data with their own knowledge about the distribution of the species. All species maps were evaluated and validated by the consulted experts. We note that for some species, the data obtained are unlikely to provide a comprehensive representation of their distribution. This is particularly clear for *Rattus norvegicus* and *Mus musculus*, which likely have much wider distributions. The scarcity of records for these species should be explained in part by their lower appeal by citizen scientists, thus having fewer records on citizen science platforms than other more iconic species.

Status of establishment: Based on our collective knowledge, we distinguished those species known to reproduce in the wild (established), from those for which there is still no evidence of reproduction (not established), and those for which reproduction is uncertain.

4. Project personnel

Principal investigators:

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Data set status and accessibility

A. Status

1. Latest update

August 2020.

2. Metadata status

Metadata are complete.

B. Accessibility

1. Storage location and medium

The data set is available online through the current publication and through Zenodo (DOI: 10.5281/zenodo.4018706). We also provide as Suppl. material 4 the R code and GIS layers to update the maps presented in Suppl. material 2. Original data files exist on the authors' personal computers in MS Excel format.

2. Contact person(s)

Fernando Ascensão: (*current address*) Centre for Ecology, Evolution and Environmental Changes Faculdade de Ciências da Universidade de Lisboa Edifício C2, 5° Piso, Sala 2.5.46 Campo Grande 1749-016 Lisboa Portugal. Email: fjascensao@fc.ul.pt.

3. Copyright restrictions

None.

4. Proprietary restrictions:

None.

Data structural descriptors

Data Set Files

1. Identity

The dataset consists of 1 file (MS Excel document), named "55597_0R-3-A_Dataset SM-1.csv" (Suppl. material 1), containing one worksheet. Each species record (line) also has the origin and IUCN conservation status. In Suppl. material 2, we also provide the distribution maps for each species. The R file, also in Suppl. material 2, contains the necessary code to replicate the maps using updated information.

2. Size

The size of "55597_0R-3-A_Dataset SM-1.csv" has 20.8 MB.

3. Format and storage mode

The file type is MS Excel. No compression scheme was employed.

4. Header information

In the worksheet, a single header row includes the species' taxonomic classification (i.e., four headers: Class, Order, Family and Species name), common name, the species origin (Africa, Asia, S. America, C. America, N. America, Europe, Oceania), reproduction in the wild (known, not established and uncertain), the IUCN conservation status, and the UTM. Time information is shown in three columns: 'Year_publication' refers to the year of publication of Atlases, books, reports and scientific papers. 'Year' refers to most accurate time of observation, frequently presented as an interval e.g., '2010–2019' and '2002(before)'. The column 'Year_numeric' is the most conservative numeric number of Year, in the previous examples would be 2019 and 2002, respectively. The column 'Source' indicates the reference from which the information was obtained. Finally, the 'key' column indicates the unique ID of citizen science platforms, allowing the online visualization of the records. For example, the key = 58020496 in iNaturalist can be retrieved by the URL: www.inaturalist.org/observations/58020496, showing a common slider.

5. Alphanumeric attributes

Alphabetic character fields.

Supplemental descriptors

A. Data acquisition

1. Data forms or acquisition methods

Available online through the current publication.

2. Computer programs and data-processing algorithms:

We provide an R script in Suppl. material 4 which allows updating the maps of species occurrences. GIS information is also provided in Suppl. material 3.

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We thank Dr. Cristiane Bastos-Silveira for her help in collecting mammal data from the National Museum of Natural History in Lisbon. FA was funded through a post-doctoral grant from Fundação para a Ciência e Tecnologia (FCT, SFRH/BPD/115968/2016). RCM work was carried out in the framework of REN Biodiversity Chair, funded by REN (Redes Energéticas Nacionais, S.A.) and FCT. MLM thanks to FCT/MCTES for the financial support to CESAM (UID/AMB/50017/2019), through national funds. Work supported by National Funds through FCT-Fundação para a Ciência e a Tecnologia in the scope of the project UIDB/50027/2020.

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Supplementary material 1

Dataset

Authors: Fernando Ascensão, Marcello D'Amico, Ricardo C. Martins, Rui Rebelo, A. Márcia Barbosa, Joana Bencatel, Rafael Barrientos, Pedro Abellán, José L. Tella, Laura Cardador, José D Anadón, Martina Carrete, Enrique Murgui, Pedro Fernandes, Sara M. Santos, António Mira, Maria da Luz Mathias, Patrícia Tiago, Eduardo Casabella, Luís Reino, Octávio S. Paulo, Henrique M. Pereira, César Capinha

Data type: table

Link: https://doi.org/10.3897/neobiota.64.55597.suppl1

Supplementary material 2

Maps

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Data type: Maps

Link: https://doi.org/10.3897/neobiota.64.55597.suppl2

Supplementary material 3

GIS

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Data type: GIS data

Link: https://doi.org/10.3897/neobiota.64.55597.suppl3

Supplementary material 4

R code

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Data type: R code

Link: https://doi.org/10.3897/neobiota.64.55597.suppl4