Nature Conservation 9: 45–67 (2014)
doi: 10.3897/natureconservation.9.8908
http://natureconservation.pensoft.net

DATA PAPER

A peer-reviewed open-access journal
Nature Conservation
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Life-history trait database of European reptile species

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Academic editor: *L. Penev* | Received 7 November 2014 | Accepted 11 December 2014 | Published 19 December 2014

http://zoobank.org/869168EE-0701-4EAD-A088-90160C27EA34

Citation: Grimm A, Ramírez AMP, Moulherat S, Reynaud J, Henle K (2014) Life-history trait database of European reptile species. Nature Conservation 9: 45–67. doi: 10.3897/natureconservation.9.8908

Abstract

Life-history data are essential for providing answers to a wide range of questions in evolution, ecology, and conservation biology. While life history data for many species, especially plants, are available online, life history traits of European reptiles are available only widely scattered in different languages and primarily in printed media. For this reason, we generated a comprehensive trait database covering all European reptile species. Data were compiled by searching the peer-reviewed and non-peer-reviewed literature. The database covers the whole of Europe and neighbouring Asian and African countries. Traits were categorised under five main headings: Activity / Energy / Habitat; Phenology; Movement; Sexual Maturity; and Morphometry. To ensure that the data were standardised, we defined trait data categories before we started compiling data. All entries were checked by at least one other person. The dataset provides a unique source for meta-analyses and modelling in ecology and conservation biology.

Keywords

Activity, Europe, life history traits, lizards, movement, phenology, Reptilia, Sauria, Serpentes, Testudines

Introduction

Large-scale analyses of drivers of biodiversity, biodiversity patterns, and global processes are gaining increasingly more importance in ecology and conservation science. Recent examples of large-scale analyses and meta-analyses on biodiversity investigated among other aspects the minimum area requirements of species (Pe'er et al. 2014), the scaling behaviour of beta-diversity (Keil et al. 2012), dispersal (Stevens et al. 2010), niche ecology (Kearney and Porter 2009, Schulte et al. 2012), the effects of climate warming on biodiversity (Deutsch et al. 2008, Sinervo et al. 2010), the effects of fragmentation of tropical forests on climate change (Pütz et al. 2014), and the monitoring of land use effects on biodiversity (Kuussaari et al. 2007, Kahl and Bauhus 2014).

Species traits play an important role in such large-scale analyses since they can affect but also respond to abiotic and biotic processes (Kleyer 1999, Chapin et al. 2000, Ilg et al. 2012, Pütz et al. 2014). Available trait information for some species also enables generalisations to species for which the trait is difficult to measure. This is of particular importance in applied biodiversity conservation when decisions have to be made for species for which knowledge is limited. .This is the case, for example, for dispersal potential in the assessment of connectivity (Stevens et al. 2010, 2013), minimum area requirements in the design of conservation areas (Pe'er et al. 2014), and the identification of species that are sensitive to fragmentation (Henle et al. 2004). The use of traits can therefore greatly improve our understanding of ecological patterns and processes and their relevance for the conservation of biodiversity.

Trait data are usually published in widely dispersed literature and therefore difficult to access. Hence, a compilation of such data in handbooks (e.g. Novosolov et al. 2013) or in databases is essential to support the study of large-scale ecological processes and patterns. Due to their key role in ecosystem processes, traits for several groups of species have been compiled and made available, e.g. several plant traits [Klotz et al. 2003 (www.biolflor.de), Kleyer et al. 2008 (www.leda-traitdatabase.org), Kattge et al. 2011 (www.try-db.org)], bees [Bees, Wasps & Ants Recording Society 2014 (www.bwars.com)], syrphids [Speight et al. 2000 (www.iol.ie/~millweb/syrph/syrphid.htm)], butterflies [Jonko et al. 2014 (http://www.lepidoptera.eu/)], amphibians [Trochet et al. 2014 (http://biodiversitydatajournal.com/articles.php?id=4123)], and birds [Koposová et al. 2014 (http://scales.ckff.si/scaletool/index.php?menu=6)]. However, we are not aware of a global species trait database that exists for reptiles although a general compilation of reptile species names and distribution exists (Uetz and Hošek 2014) and a compilation of trait data have been published in printed form e.g. for Mexico (Sinervo et al. 2010) and some selected traits of 641 lizard species from around the world (Novosolov et al. 2013). For this reason, within the project SCALES (Henle et al. 2010) we developed a trait database covering all European reptile species since the project was predominantly based in Europe. We mainly aimed to obtain phenological and movement data from across the geographic distribution of the species covered. However, other information on activity, energy, habitat, sexual maturity, and morphometry were also included.

The reptile trait database is an open access database. A user-friendly interface including browse options is provided on the SCALES project webpage (http://scales.ckff.si/scaletool/), but we also provide access to raw data through Dryad (doi: 10.5061/dryad.hb4ht). We will keep the database active and update it frequently. We therefore invite all of our readers to provide published data that can be added to the database. If you are interested in submitting data, please contact the authors and send the respective papers. The data will be checked by us for plausibility (especially non-peer-reviewed publications) before being entered into the database.

Data resources

Data published through Dryad: http://dx.doi.org/10.5061/dryad.hb4ht
Data published through SCALETOOL: http://scales.ckff.si/scaletool/?menu=6&submenu=0

Project details

Project title: Securing the conservation of biodiversity across administrative levels and spatial, temporal, and ecological scales (SCALES) (Henle et al. 2010)
Subproject: Trait database of reptile life histories
Personnel: Klaus Henle (Project Coordinator, Taxonomic Expert, and Data Compilation), Annegret Grimm (Data Compilation and Data Manager), Ana María Prieto Ramírez (Data Compilation), Sylvain Moulherat (Data Compilation), Julie Reynaud (Data Compilation)
Funding: FP7 integrated project SCALES; EU Grant no. 226852

Taxonomic coverage

General taxonomic coverage description: The coverage of this database spans the class of Reptilia in the Kingdom Animalia. The database collates the species traits of all 122 European species belonging to 43 genera recognized by the SEH Atlas of 2004 (Gasc et al. 2004), which was the most up-to-date list when we started our data compilation (referred to as *SEH taxonomy* in the database; Suppl. material 1: Table S1). Since the atlas was published, many names changed both at and below the generic level, primarily by splitting previous taxa. Currently, there are several lists of European reptile species available (Sindaco and Jeremčenko 2008, Cox and Temple 2009, Speybroeck et al. 2010, Mayer 2013, Glandt 2014, Sillero et al. 2014, Uetz and Hošek 2014) that deviate from each other in recognition of some taxa and also in terms of geographic coverage (see below). Unfortunately, justifications for the acceptance or rejection of taxa are rather limited for several of these lists, with Speybroeck et al. (2010) being

the most comprehensive one. We therefore largely followed them but evaluated several more recent name changes by using original publications. We agree with Speybroeck et al. (2010) that the scientific name of a species should only be changed if there is strong evidence of it being necessary to reflect evolutionary history and if data are supported by sound evidence. On the other hand, further taxon splitting is a necessary consequence of advances in systematics. Strong evidence for us means that a name change is backed by sufficiently comprehensive sampling, by consistent evidence from more than one character set analysed with appropriate statistical methods, and by sound biogeographic scenarios. For inclusion in the database, an additional criterion had to be fulfilled: the distribution of the taxa involved must have been worked out sufficiently to allow allocation of life-history data to a particular taxon without uncertainty. This resulted in 144 recognized species belonging to 59 genera (named *current taxonomy* in the database; Suppl. material 1: Table S1). Deviations from Speybroeck et al. (2010) and Sillero et al. (2014) are listed and justified in Suppl. material 2: Table S2. The database is designed in such a way that taxa (European or non-European) can be added without a need to change the structure of the database. The database can be searched using both the original names as in Gasc et al. (2004) as well as the updated names. We allocated data that were published before species complexes were split to the relevant new taxa if this allocation could be made with certainty.

Taxonomic ranks

Kingdom: Animalia.
Phylum: Chordata.
Class: Reptilia.
Order: Testudines, Squamata (Amphisbaenia, Sauria, Serpentes).
Family: Agamidae, Anguidae, Blanidae, Boidae, Chamaeleonidae, Cheloniidae, Colubridae, Dermochelyidae, Emydidae, Gekkonidae, Geomyidae, Lacertidae, Lamprophiidae, Natricidae, Phyllodactylidae, Scincidae, Sphaerodactylidae, Testudinidae, Typhlopidae, Viperidae.
Family names of reptiles also changed since 2004. Our list follows the family names accepted in the TIGR global reptile database (Uetz and Hošek 2014).
Common Name: Reptiles, Snakes, Lizards, Tortoises.

Spatial coverage

General spatial coverage: Our database covers Europe. Neither politically nor geographically has the boundary of Europe been universally agreed upon and overviews of the distribution of reptile species used different existing delimitations (Mertens and Wermuth 1960, Böhme 1981, Gasc et al. 2004, Cox and Temple 2009, Speybroeck et al. 2010, Sillero et al. 2014). We followed Mertens and Wermuth (1960,) Böhme

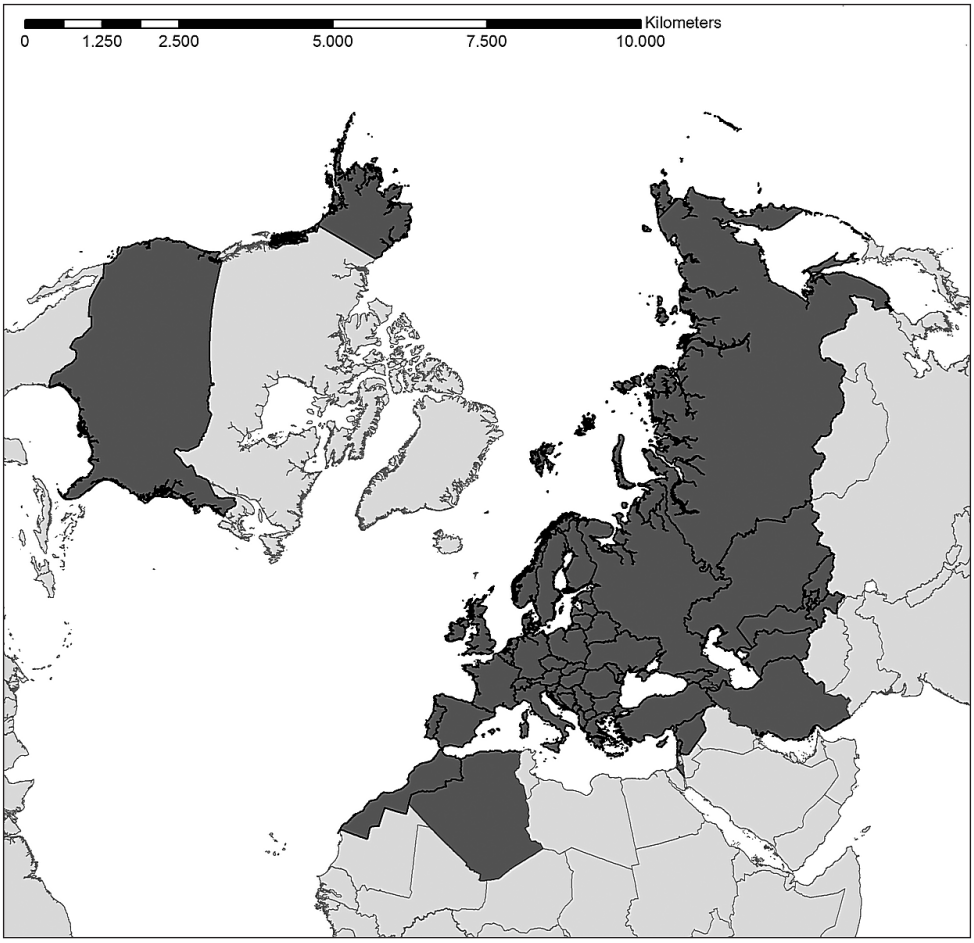

Figure 1. Spatial coverage of the database. Grey countries (46 European countries plus neighbouring countries in Asia, namely Armenia, Azerbaijan, Georgia, Iran, Israel, Kazakhstan, Kyrgyzstan, Lebanon, Russia, Syria, Tajikistan, Turkey, Turkmenistan, and Uzbekistan, plus the African countries Algeria and Morocco) are covered by the database. This map shows the countries in general and not the region where data points are from. This map was created using ArcGIS® software by Esri (www.esri.com) with an European Lambert Azimuthal Equal Area projection. © Esri, all rights reserved.

(1981), and Gasc et al. (2004), using the following delimitation of "Europe": reaching across the Ural Mountains, the Ural River, the Caspian Sea, the main Caucasus Divide, the Black Sea, including the Marmara Sea and the Aegean Sea along the divide of the European and Asiatic shelf as well as the European and African tectonic plates (Figure 1). Mascarene Island and the Azores, which politically but not geographically belong to Europe are currently not included, nor are the Selvagenes and the Canary Islands. Our data therefore covers 46 European countries. Speybroeck et al. (2010), in contrast, did not include former republics of the Soviet Union that are partially or completely within Europe (see Suppl. material 2: Table S2.1). Cox and Temple (2009)

are inconsistent in including Greek islands on the Asian shelf but excluding Mediterranean Spanish islands on the African shelf. They further included the Mascarene Island, Selvagenes, and the Canary Islands. Our database is designed in such a way that countries or other geographic entities can be added without a need to change the database structure.

As we wanted to cover European species comprehensively, we also included extra-limital data in the database. We found data for neighbouring countries in Asia (Armenia, Azerbaijan, Georgia, Iran, Israel, Kazakhstan, Kyrgyzstan, Lebanon, Russia, Syria, Tajikistan, Turkey, Turkmenistan, and Uzbekistan) and Africa (Algeria, Morocco) (Figure 1). In addition, case studies from the USA about the invasive European gecko *Hemidactylus turcicus* are included as such data are highly valuable for an assessment of invasion processes of European species. The designation of geographical entities in the database does not imply the expression of any opinion whatsoever on the part of the data compilers concerning the legal status of any country, territory or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. It is worth noting that in some older references, older geographic names are used that are difficult to match with modern names; in such cases we either retained the old names or used a more inclusive geographic name that encompasses the name in question. The database enables all geographic names to be listed that are used in the database.

Temporal coverage

Currently until mid-2014, life-history trait data were published primarily after the mid-1960s and for many Eastern and southern European taxa primarily in the last 10 years.

Methods

Method step description: We carried out a literature survey in the form of focal species surveys of all European reptiles. A very useful starting point was the Handbook of European Reptiles (in German) (Böhme 1981), as well as French (Arnold and Ovenden 2010) and Spanish (Escarré and Verricard 1981, Salvador and Marco 2009) handbooks and our own extensive collection of life-history publications. These sources already compiled a substantial part of the relevant publications. For species, for which we retrieved no data in above sources, we conducted targeted searches in the ISI web of knowledge, in Google Scholar, and in Google published in English, German, French, and Spanish. We tried to trace any potentially relevant sources cited in the publications found from these searches. Moreover, we presented our project at herpetological conferences to expand our literature sources from experts. However, we only entered data from published literature into the database. The publications that were used to provide data for the database are listed in References. Together, these sources covered

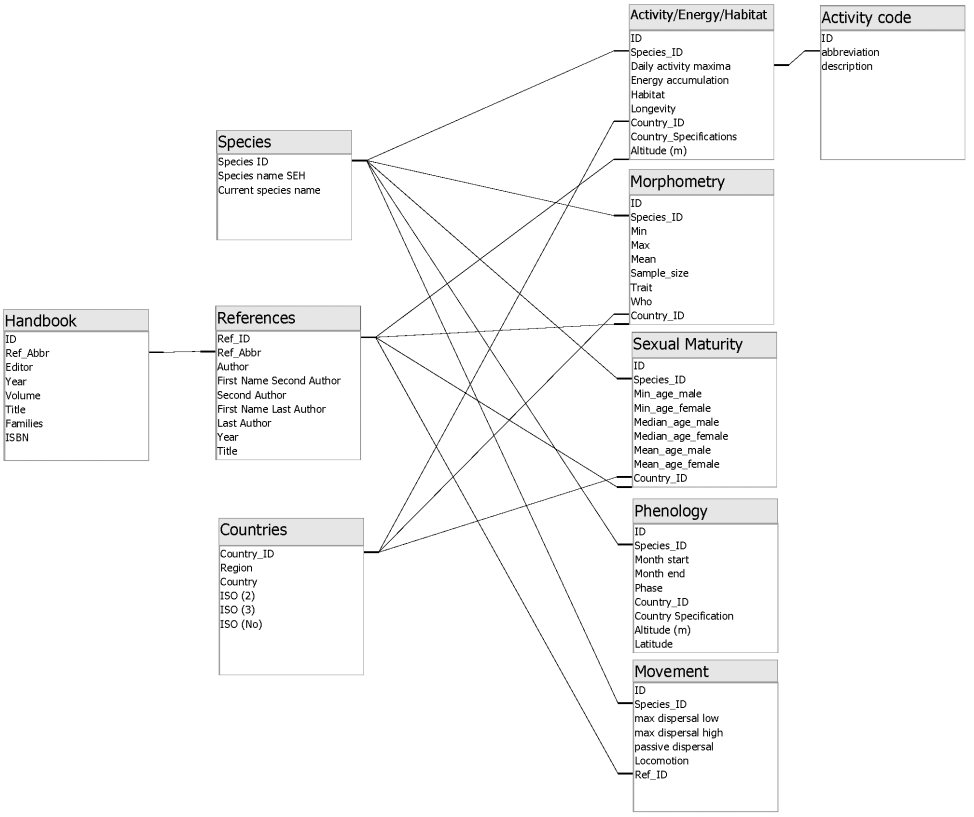

Figure 2. Graphical representation of the database including relationships between the basic tables (*Species; References; Countries*) and the trait tables (*Activity / Energy / Habitat; Sexual Maturity; Phenology; Movement; Morphometry*).

all European reptile species except a few recently described taxa, such as *Dalmatolacerta montenegrina*, for which no life-history data have been published.

Study extent description: All European reptile species are covered in the database without accounting for temporal restrictions as to when the study was conducted.

Sampling description: Before starting the literature search, we decided upon a database structure (Figure 2, described below) and the main topics to be covered. The main topics selected were activity and energy traits, phenological traits, movement/dispersal traits, age at sexual maturity, and morphometry. The literature was searched using specific key words linked to these topics. Detailed definitions of the categories are given below.

Quality control description: All data entries were checked by at least one person other than the one who entered the data. This check also included a plausibility check of the original data. We did not include any data in the database that we could not allocate with certainty to the categories used by us or that were ambiguous in terms of the entity to which they applied.

Dataset descriptions

Our database comprises two sections: basic information and actual trait data. In the basic section, general information about taxonomy, references, and countries is stored. The trait data section is divided into the following: *Activity / Energy / Habitat; Phenology; Sexual Maturity; Movement; and Morphometry*.

Object name: Trait database of reptile life histories
Character encoding: UTF-16
Format name: Microsoft Access Database
Formatversion: Microsoft® Access® 2010 (14.0.7104.5000) SP2 MSO (14.0.7116.5000) as part of Microsoft Office Professional Plus 2010
Distribution: http://scales.ckff.si/scaletool/?menu=6&submenu=0 and http://dx.doi.org/10.5061/dryad.hb4ht
Publication date: 2014–01–21 and 2014–12–08, respectively
Language: English
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Metadata descriptions

Our relational database is divided into a basic section and the actual trait section (Figure 2). The basic section comprises three tables: *Species*, which lists all 144 European reptile species that we recognised (see the section on taxonomic coverage); *References*, listing all published sources for data extraction (166 in total); *Countries*, listing 46 European, 14 Asian, and 2 African countries and the USA, which is where reptile trait data stem from including their ISO 2, ISO 3, and ISO No codes. In addition, we have names for supranational geographic regions, such as the Caucasus or the Mediterranean, for data where it is not clear from the original source to which country they apply.

In the trait data section, five main tables were created according to the five main topics (*Activity / Energy / Habitat; Phenology; Movement; Sexual Maturity; Morphometry*). All tables are provided with species ID, country ID, country specifications (geographic regions within countries if published), altitude (if published), latitude (if published), longitude (if published), and reference ID so that each data point can be tracked correctly. The definitions and contents of the five tables are described in the following. The words in italics stand for column headings. Capital letters are used for the five main tables.

Activity / Energy / Habitat: Data about *daily activity* describe activity peaks during the day including activity switches within the year. These activity patterns were defined as ten different categories: (1) cn: crepuscular/nocturnal; (2) dn: active the entire

day, no circadian rhythm (diurno-nocturnal); (3) tn: nocturnal, but thermoregulation during the day possible; (4) hu: humidity dependent, no circadian rhythm; (5) 1: one activity peak during the day throughout the year (unimodal); (6) 2: two activity peaks during the day throughout the year (bimodal); (7) as1a: activity shift: summer: one peak during dusk or night (crepuscular or nocturnal), spring/autumn one peak during the day (diurnal) [it is possible that species show bimodal activity between the switch diurnal to nocturnal]; (8) as1b: activity shift: one peak during the day throughout the year, shifted to the morning during the summer; (9) as2a: activity shift: in summer two peaks during the day, spring/autumn: one peak during the day but diurnal throughout the year; (10) as2b: activity shift: summer: one peak during dusk or night (crepuscular/nocturnal), spring/autumn: two peaks during the day (morning/afternoon).

Data about *energy accumulation* denote when species accumulate energy for reproduction (i.e., spring, summer, autumn, or from the previous year – text strings). Moreover, their *habitat* (free text string using general habitat descriptions) and their maximum *longevity* (in years) were listed.

Phenology: Phenological traits refer to four *phases*: the first and second breeding season, aestivation, and hibernation. Each phase is specified by a specific *start* and *end month*. If a publication mentioned a range for the start or end month for a particular area, we used the first month mentioned as the start month and the last month mentioned as the end month for the breeding seasons (to specify the maximum duration available for breeding). For hibernation, in contrast, we used the last month to specify the start month and the first month to designate the end month; thus hibernation data allow a calculation of the maximum time (in months) available for activity.

Movement: Data on movement cover true dispersal, home range movement, and migration because most references do not sufficiently differentiate between these processes. However, if data were sufficiently explicit, we solely used dispersal data. Movement data larger than 250 m were rounded off to 250 m. The reference time span is not necessarily one year but depends on the study described in the original paper. The data in the database are the highest values given by the reference publication for a specific reference area. If a range of maximum dispersal/movement was given in the reference, we provide the lower value in the column *maximum movement low* and the higher value as *maximum movement high*. If no range was given, data were allocated to the latter. Furthermore, *passive dispersal* provides information about whether a species may be dispersed passively through human activities. In addition we provide information about the type of *locomotion* (e.g. swimmers, climbers, runners, or combinations between them).

Sexual Maturity: Age at sexual maturity (in months) was defined as the *minimum, median*, or *mean age* for *males* respectively *females*. The minimum age refers to the lowest age at sexual maturity provided for a specific reference for a specific country. The median age is the age at which 50% (usually most) individuals reach sexual maturity. Mean age is only given if explicit values were provided by the relevant publication.

Morphometry: In the last section, morphometric data are provided as *minimum*, *maximum*, and *mean* values (depending on the data given in the consulted literature).

If published, a *sample size* was listed. *Traits* were specified as mass, length, width, number, or size. These traits always refer to denoted parts of the population (*Who*), such as females, males, hatchlings, juveniles, eggs, or clutches. This structuring allows a maximum number of possible combinations, while using minimal memory space.

Since our database was built as a relational database, IDs between the basic and the trait tables were linked to each other for fast searches and queries (Figure 2).

Metadata language: English
Date of metadata creation: 2014–09–12
Hierarchy level: Database

Acknowledgements

Thanks are due to all those who provided data for this compilation. Funding for this study was provided by the EU FP-7 project SCALES (Henle et al. 2010; www.scales-project.net; grant no. 226852).

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Supplementary material 1

Species names used in our database and used in the Societas Europaea Herpetologica (SEH) atlas

Authors: Annegret Grimm, Ana María Prieto Ramírez, Sylvain Moulherat, Julie Reynaud, Klaus Henle

Data type: Table.

Explanation note: The table matches the species names in the SEH atlas with the updated speceis names used in our database. It thus provides the two species list that can be used to search the database.

Supplementary material 2

Comments on taxonomy and species coverage

Authors: Annegret Grimm, Ana María Prieto Ramírez, Sylvain Moulherat, Julie Reynaud, Klaus Henle

Data type: Tables.

Explanation note: The supplementary material consists of several tables that explain differences between our updated list of species names to the lists used by Sillero et al. (2014) in their new SEH list of species and the list of Speybroeck et al. (2010).