The Glasgow Naturalist (online 2024) Volume 28, Part 2 https://doi.org/10.37208/tgn28225

Distribution of non-native terrestrial and freshwater amphibians and reptiles in Scotland

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ABSTRACT

Surveillance of non-native species is important for biosecurity and ecological reasons. This paper presents a baseline of the distribution of non-native terrestrial and freshwater amphibian and reptile species in Scotland. Multiple datasets were used to confirm which non-native terrestrial and freshwater species of amphibians and reptiles are currently present in Scotland, and map their known distribution. Citizen Science records were found to be extremely useful when photographs were included. Four non-native terrestrial and freshwater amphibian and reptile species were found to be present in Scotland, including Alpine newt (*Ichthyosaura alpestris*), sand lizard (*Lacerta agilis*), Chinese pond turtle (*Mauremys reevesii*), and common slider (*Trachemys scripta*).

INTRODUCTION

Although there have been studies focused on distribution of particular non-native species in the U.K. (notably non-native turtles and Alpine newt *Ichthyosaura alpestris*), little has been published regarding the distributions of non-native amphibians and reptiles in Scotland (McInerny & Minting, 2016; Allain, 2019; Allain & Lynn, 2021). Non-native species can disrupt native ecology and may be carriers of diseases novel to native species (Kraus, 2015). For example, the spread of chytrid fungi (*Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal)) is linked to introduced species, and these pathogens are causing global amphibian extinctions through the disease they can cause – chytridiomycosis. In a Scottish context, Alpine newt can be an asymptomatic or "silent" vector for these fungi (Cunningham & Minting, 2008; Wilkinson *et al.*, 2010; Smith, 2014; Cunningham *et al.*, 2019).

Under the Wildlife and Countryside Act 1981 (as amended in Scotland by the Wildlife and Natural Environment (Scotland) Act 2012), it is illegal to release an animal to a location outside its native range, allow an animal to escape from captivity to a location outside its native range, or otherwise cause an animal not in the control of any person to be at a location outside its native range.

By collating existing records, this paper presents a baseline of the distribution of non-native terrestrial and freshwater amphibian and reptile species in Scotland, providing a basis for decision making and future surveillance.

METHODS

Existing records of non-native terrestrial and freshwater amphibian and reptile species in Scotland were collated from a range of data sources, as summarised in Table 1. For this study, terrestrial and freshwater species considered native were defined using McInerny & Minting (2016) and included common frog (*Rana temporaria*), common toad (*Bufo bufo*), natterjack toad (*Epidalea calamita*), great crested newt (*Triturus cristatus*), palmate newt (*Lissotriton helveticus*), smooth newt (*Lissotriton vulgaris*), common lizard (*Zootoca vivipara*), slow-worm (*Anguis fragilis*), and adder (*Vipera berus*).

Furthermore, barred grass snake (*Natrix helvetica*) has not been included as a non-native reptile, as its status in Scotland remains unclear, with evidence suggesting it is a native species which has been present and possibly breeding in the south of the country for a century or more (Cathrine, 2014, 2016). Additional research is required to confirm if barred grass snake is native or non-native.

Any other species of amphibian and reptile were considered non-native, although species unable to persist in the wild in Scotland due to climatic conditions were not included. Collated data were plotted in ArcGIS Pro, and thoroughly verified. Verification involved checking provenance/recorder, grid references, notes, descriptions, and habitat, as well as photographs where available.

RESULTS

A total of 101 records of non-native terrestrial and freshwater amphibian and reptiles was collated, distributed over 19 10 km squares, and representing four species: Alpine newt, sand lizard, Chinese pond turtle, and common slider. Table 2 summarises the results, and distribution maps are provided for each non-native amphibian and reptile species identified in Fig. 1.

Alpine newt

Alpine newt is the most frequently recorded of the four non-native species present in Scotland, with 62 records. Its distribution appears to be disjunct, with four apparently geographically distinct populations:

Data holder	Data access method	Licence*
Amphibian and Reptile Conservation Trust	NBN Atlas	CC BY, CC BY-NC
Amphibian and Reptile Groups of the UK	NBN Atlas, Record Pool	CC BY-NC
Central Scotland Amphibian and Reptile Group	Record Pool	CC BY-NC
Caledonian Conservation Ltd	Direct	CC BY-SA
Clyde Amphibian and Reptile Group	Record Pool	CC BY-NC
Froglife	NBN Atlas	CC BY-NC
Glasgow Museums Biological Records Centre	Direct	Specific permission
Lothian Amphibian and Reptile Group	Record Pool	CC BY-NC
Scotland's Environment Web and Biological Records Centre	NBN Atlas	OGL
Steven Allain and Vanessa Lynn	NBN Atlas	CC BY-NC
Steven J R Allain	NBN Atlas	CC BY-NC
The Wildlife Information Centre	NBN Atlas	CC BY-NC

*Data licences
CC BY = Use provided attribution is given to data holder.
CC BY-NC = Use for non-commercial purposes only, provided attribution is given to the data holder.
CC BY-SA = Use provided attribution is given to the data holder, and any outputs using the data must be shared under the same licence.
OGL = Open Government Licence. Use provided attribution is given to the data holder.
Specific permission = Specific written permission was provided from the data holder allowing use of data for this specific research purpose.

Table 1. Details of data sources used to collate non-native amphibian and reptile records in Scotland (including the method by which data were accessed, and the licence under which use is granted for this non-commercial research).

OS National Grid 10 km square	Species			
	Alpine newt (*Ichthyosaura alpestris*)	**Sand lizard (*Lacerta agilis*)**	**Chinese pond turtle (*Mauremys reevesii*)**	**Common slider (*Trachemys scripta*)**
NM15		1		
NN71				1
NO00	2			
NO21				2
NO32				1
NO52				1
NO55				2
NS28	1			
NS47				3
NS56			1	16
NS66				6
NS67				1
NS76	2			
NS79				2
NT16	1			
NT17	18			
NT26	1			
NT27	37			2
NX76				5
Total records	**62**	**1**	**1**	**42**
Total 10 km squares	**7**	**1**	**1**	**12**

Table 2. Summary of collated non-native amphibian and reptile records, including where they were located (OS National Grid 10 km square), total records, and total OS National Grid 10 km squares each species has been recorded from.

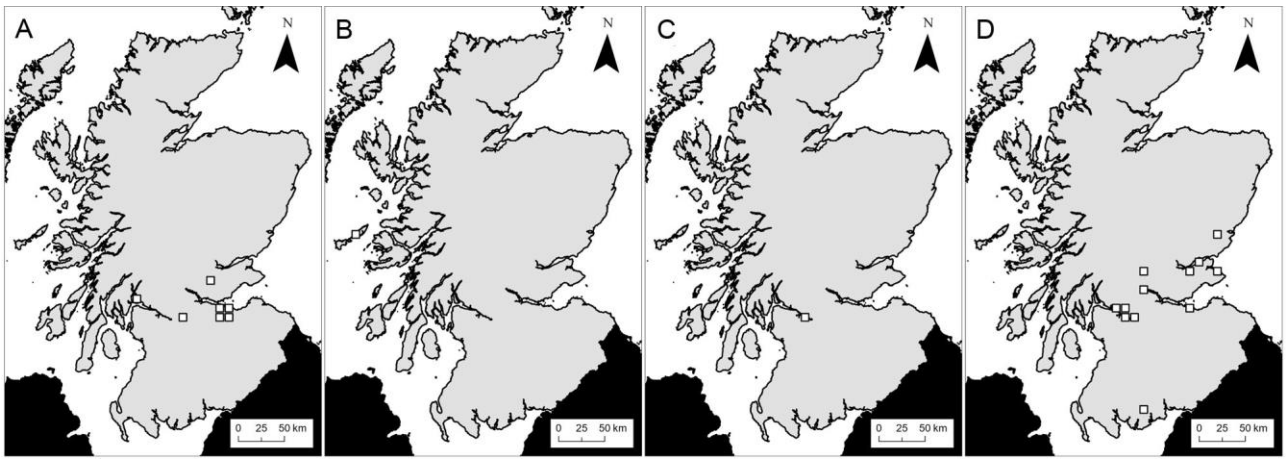

Fig. 1. Maps showing distribution of non-native amphibian and reptile species in Scotland. (A) Alpine newt (*Ichthyosaura alpestris*) (B) sand lizard (*Lacerta agilis*). (C) Chinese pond turtle (*Mauremys reevesii*). (D) Common slider (*Trachemys scripta*). White squares indicate occurrence at OS National Grid 10 km resolution. Data sources: Esri, Maxar, Earthstar Geographics, the GIS user community, and the data holders detailed in Table 1.

Edinburgh (City of Edinburgh), Dollar (Clackmannanshire), Glenboig (North Lanarkshire), and Helensburgh (Argyll & Bute). Although found in seven OS National Grid 10 km squares, the majority of records (50) are from just two: NT16 and NT26. This reflects the large number of records from Edinburgh and its surroundings (Fig. 2). Records dated from 1987 to 2023.

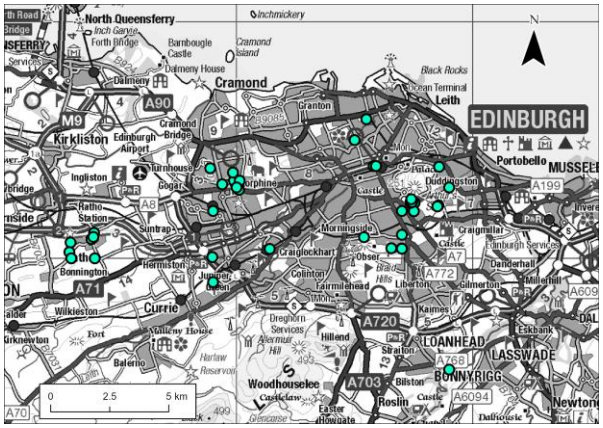

Fig. 2. Map showing distribution of Alpine newt (*Ichthyosaura alpestris*) in Edinburgh and the surrounding area at highest resolution possible (coloured dots indicate record locations). Data sources: Esri, Maxar, Earthstar Geographics, the GIS User Community, and the data holders detailed in Table 1. Contains Ordnance Survey data © Crown copyright and database right 2023.

Sand lizard

The only verified record of a population of sand lizard in Scotland is from the island of Coll, dating from 1970.

Chinese pond turtle

There is only a single record of one Chinese pond turtle in Scotland, from Glasgow Botanic Gardens in 2022.

Common slider

Common slider is the most widely distributed non-native amphibian or reptile species in Scotland, recorded from 12 OS National Grid 10 km squares. It is also the second most frequently recorded non-native species, with 42 records. There are 10 distinct population centres: five urban and five rural. The majority of records (25) are from Glasgow and Clydebank (Fig. 3). Record dates ranged from 1993 to 2022. There are three recognised sub-species of common slider: red-eared slider (*T. scripta elegans*), yellow-bellied slider (*T. scripta scripta*), and Cumberland slider (*T. scripta troostii*) (Seidel & Ernst, 2006). Of these red-eared and yellow-bellied slider have definitely been recorded in Scotland. However, many records are at species level only, and so it is not possible to determine abundance of either of these recorded sub-species, or confirm presence or likely absence of the as yet unrecorded Cumberland slider.

Fig. 3. Map showing distribution of common slider (*Trachemys scripta*) in Glasgow and the surrounding area at highest resolution possible (coloured dots indicate record locations). Data sources: Esri, Maxar, Earthstar Geographics, the GIS User Community, and the data holders detailed in Table 1. Contains Ordnance Survey data © Crown copyright and database right 2023.

DISCUSSION

Alpine newt

Until 2016, Alpine newts were only recorded from Edinburgh, Ratho, and Helensburgh. These were considered to represent isolated populations unable to

disperse due to the urban environment, despite the species being found progressively further from Ratho in railway embankments during maintenance works, and the close proximity of this population to the Union Canal in which all three native newt species have been recorded as breeding (Wilkinson *et al.*, 2010; McInerny & Minting, 2016; Robbemont *et al.*, 2023; Caledonian Conservation Ltd., 2024). It has been assumed that the Edinburgh populations relate to a single origin associated with a university, and that the Helensburgh population is a separate occurrence relating to private garden ponds (Peter Leach, pers. comm.; Irving, 1987; Ball *et al.*, 2023). However, in 2016, another population was reported from Glenboig, 40 km west of the Ratho population, and 45 km east south-east of the Helensburgh records, and included in the distribution map published in McInerny & Minting (2016). The Glenboig population is not included in the most recent publication regarding the distribution of Alpine newt in the U.K. (Allain & Lynn, 2021), as the records were not contained within the datasets used in that study (Steven Allain, pers. comm.). Furthermore, a fourth population centre was confirmed near Dollar, Clackmannanshire in 2021, located 30 km north north-west of the Ratho records, and on the other side of the Firth of Forth.

Due to the geographical barriers to dispersal and distances involved, it seems likely that the four main population centres for Alpine newt in Scotland relate to separate introduction events. However, there is evidence of dispersal, particularly in the Edinburgh area. Furthermore, Alpine newts have been found to hibernate in embankments within 1 m of the Union Canal at Ratho, and it is likely that this will become a vector for dispersal throughout the central belt, if it is not already.

The findings regarding the distribution of Alpine newts in Edinburgh and the wider area are of particular interest. It has been believed that there are three populations of Alpine newts in Edinburgh: Duddingston, Mortonhall Golf Course, and Ratho (Ball *et al.*, 2023). These have been widely considered to be isolated and unable to disperse due to the surrounding urban environment (Peter Leach, pers. comm.; McInerny & Minting, 2016; Ball *et al.*, 2023). It is also commonly assumed that all of these populations originated from released overstock of Alpine newts at a local university between the 1950s and 1970s, before release of (most) non-native species became illegal in Scotland (McInerny & Minting, 2016; Ball *et al.*, 2023). However, a recent mitochondrial DNA study that sampled Alpine newt throughout the U.K. included the Duddingston, Mortonhall Golf Course, and Ratho populations and found that the latter was genetically distinct from the first two (Ball *et al.*, 2023). This is unsurprising, as the Duddingston and Mortonhall Golf Course populations are both close to the local university which is believed to be the origin, while Ratho is over 10 km west. Furthermore, the origin of the Ratho Alpine newt population is known and more recent, having been introduced in the 1990s in an attempt to prevent a local development (Peter Leach, pers. comm.). The newts were mistakenly believed to be great crested newts, a European Protected Species under the European Union (EU) Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora).

The concept of three distinct populations of Alpine newts within Edinburgh, unable to disperse through the urban environment, appears to be incorrect based on the results of this study. Alpine newts were found to be widespread throughout Edinburgh and the wider area (Fig. 2 and Table 2). Whether this relates to dispersal or multiple introductions is unclear. It should be noted Alpine newts were also known to be present in a pond at Corstorphine Hill (between Duddingston/Mortonhall Golf Course and Ratho) in the 1990s, and a local garden centre sold this species of newt until the 2020 COVID-19 pandemic lockdown.

The previous view of Alpine newts having a limited distribution at three or four population centres, unable to disperse, with one estimate of occurrence being in as few as ten ponds (McInerny & Minting, 2016), is no longer accurate, and this species is more widely distributed throughout central Scotland. Alpine newts are able to breed in Scotland – mating and all life-stages have been recorded (McInerny & Minting, 2016) – and so range expansion is likely if there are no barriers to dispersal.

Alpine newts are native to many regions of Europe, but not to any part of the U.K. They are widespread throughout Europe, although have been introduced to some locations (Robbemont *et al.*, 2023). Although the Duddingston and Ratho populations were found to be genetically distinct, they were also found to have originated from the same broad population (Ball *et al.*, 2023; Robbemont *et al.*, 2023).

Sand lizard

Sand lizards were introduced to the island of Coll in 1970 and 1971, before the release of (most) non-native species became illegal in Scotland (McInerny & Minting, 2016). Thirty-seven individuals were collected from a development site in Dorset and released in suitable habitat at Crossapol to safeguard these individuals and to investigate the climatic tolerance of the species (Langton & Beckett, 1995; Bowler & Hunter, 2007; McInerny & Minting, 2016). The population has remained stable, possibly increasing slightly, and does not appear to have dispersed to other locations on the island (McInerny & Minting, 2016). It is worth noting that Coll has relatively limited suitable habitat for this species compared with the neighbouring island of Tiree. The sand lizard is native to much of Europe, including England and Wales, and is a European Protected Species within its native range. This species is relatively frequently recorded in Scotland by the public using Citizen Science platforms. However, other than those located on Coll, records have been found to relate to green common lizard morphs based on photographs, habitat, or communication with the recorder.

Chinese pond turtle

A single Chinese pond turtle specimen was recorded at Glasgow Botanic Gardens in 2022, the first reported record for the U.K. (Cathrine & Monir, 2022). The Chinese pond turtle is a species of terrapin found in China, Taiwan, the Korean Peninsula (excluding Jeju Island), and Japan, although recent genetic studies indicate it is likely to have been artificially introduced to the latter country (Suzuki *et al.*, 2011; Oh *et al.*, 2017; Rhodin e*t al.*, 2021). This species has recently been found in the Republic of Ireland (Rob Gandola, pers. comm.).

It is unlikely that *M. reevesii* would establish functional populations in Scotland, as the climate is even less suitable for this species than for *T. scripta* (see below), but individuals may persist outdoors for a considerable period, as this terrapin species is known to live for over 20 years (Kopecky *et al.*, 2013; Myhrvold *et al.*, 2015).

Common slider

The common slider is the most widely distributed non-native species found in this study. The distribution was found to be largely consistent with that reported in Allain (2019), the most recent U.K. publication for this species. However, the common slider was found to be more widely distributed than previously thought, with this study confirming presence in Dumfries & Galloway and Perthshire.

While Glasgow and Clydebank appear to be the hotspots for the common slider in Scotland (Fig. 3 and Table 2), it has been recorded from many different locations, with ten broad geographic centres. While non-native species are often considered to be an urban issue, this does not appear to be true of common sliders in Scotland, as half of the centres are rural. However, many of these rural locations are wildlife reserves, country parks, or close to wildlife parks with exotic specimens. The only exception to this is the record from Dumfries & Galloway, which is genuinely remote from public attractions and human settlements.

The common slider originates from south-eastern and central U.S.A. and northern Mexico, is highly invasive, and now occurs in many other countries, including within Europe (Seidel & Ernst, 2006; Kopecky *et al.*, 2013). It can cause significant negative impacts on native ecology, and is included in the IUCN list of the 100 most invasive species (Lowe *et al.*, 2000). Although breeding attempts have been confirmed in Scotland, the climate is unsuitable for egg development, meaning populations are limited by individual lifespans, although this species can live for over 20 years, and as long as 40 years in exceptional cases (Beebee & Griffiths, 2000; Cathrine & Monir, 2022). They can therefore persist for a long time in a waterbody depending on age at release or escape (Wareham, 2008; Myhrvold *et al.*, 2015; McInerny & Minting, 2016; Allain, 2019). For example, the author is aware of an individual red-eared slider that has been present in a rural pond in Scotland for 20 years.

Common sliders are popular pets, and sales first peaked when the "Teenage Mutant Hero Turtles" (known as "Teenage Mutant Ninja Turtles" in other countries) animated series debuted in the U.K. in 1989 (Beebee & Griffiths, 2000; Allain, 2019). Young *T. scripta* would be purchased for children, with parents not realising how quickly and how large they grow. After outgrowing enclosures, these unwanted pets would be released into larger waterbodies. Some specimens observed by the author have shown signs of restricted carapace growth caused by being kept in an inappropriately small enclosure for some time. Sales of common sliders continue to be linked with the popularity of the "Teenage Mutant Ninja Turtles" franchise.

The most commonly encountered sub-species in the U.K. is the red-eared slider, which is unsurprising as this is the most attractively marked of the three, with striking red lines on the head. The second most commonly encountered sub-species is the yellow-bellied slider, while the least frequently recorded is the Cumberland slider which is also the dullest marked sub-species (Allain, 2019; Cathrine & Monir, 2022).

CONCLUSIONS

Scotland's climate is unsuitable for many non-native terrestrial and freshwater amphibians and reptiles. However, there are at least four species which persist in the wild, including two which are successfully breeding - Alpine newt and sand lizard. It is possible that climate change may result in conditions becoming suitable for Chinese pond turtle and common slider egg development, and for other non-native amphibian and reptile species to become established.

Non-native species can have a negative impact on native biodiversity. Notably, the spread of disease is a serious risk, and Alpine newts are known to be asymptomatic carriers of chytrid fungi which can cause mortality and even extinction in other species (Cunningham & Minting, 2008; Wilkinson *et al.*, 2010). Although no chytrid has been identified from Alpine newt populations in Scotland, sampling has been based on the generally assumed limited distribution (Cunningham & Minting, 2008; Smith, 2014; Cunningham *et al.*, 2019). This study has shown that Alpine newts are far more widespread in Scotland than previously assumed.

Non-native species can also be disruptive to local ecology (Kraus, 2015). Notably, *T. scripta* is one of the 100 most invasive species in the world and can cause declines in native species through predation and competition (Lowe *et al.*, 2000; Kopecky *et al.*, 2013; Cathrine & Monir, 2022).

Records of non-native terrestrial and freshwater amphibians and reptiles in Scotland are predominantly from heavily populated urban areas. There are two possible reasons for this. Non-native species are more likely to be introduced where there are higher densities of humans or wildlife records are more likely to be seen and reported via Citizen Science platforms from areas with higher densities of humans. It is likely that both of these factors are influencing the known distribution of

non-native terrestrial and freshwater amphibians and reptiles in Scotland. It is important that future surveillance of non-native terrestrial and freshwater amphibians and reptiles includes rural areas. Targeted surveys for Alpine newts along the Union Canal are particularly critical for understanding the distribution of this species.

ACKNOWLEDGEMENTS

The author would like to thank Roger Downie for his support, encouragement, and patience. In addition, thanks are also due to Steven Allain, Niall Currie, Gary Hovell, Paul Hudson, Angela Julian, Peter Leach, Gareth Sloan, Claire K. Smith, and Richard Weddle. Furthermore, acknowledgement is due to Caledonian Conservation Ltd. which provided staff time and resources as part of its Corporate Social Responsibility and dedication to furthering our knowledge of the natural world to benefit people and wildlife.

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