Chapter 7

# Amphibian and Reptile Conservation in Scotland: Focus on the Great Crested Newt *Triturus cristatus* and the European Adder *Vipera berus*

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Additional information is available at the end of the chapter

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**Abstract**

Scotland, due to its geographical location and climate, has a relatively limited number of species of amphibians and reptiles. However, many of these are found widely across the country. As representatives of amphibians and reptiles in Scotland, this chapter will focus on the great crested newt *Triturus cristatus* and the European adder *Vipera berus*. For both species it will describe their distribution, habitat requirements, life cycles, population estimates and trends, legal protection and threats. Furthermore, it will outline recent conservation projects in Scotland showing how these creatures can live both in close proximity to humans and in developed landscapes relevant for their conservation elsewhere.

**Keywords:** Scotland, great crested newt, *Triturus cristatus*, common European adder, *Vipera berus*, biology, conservation

## 1. Introduction

Amphibian and reptile populations of numerous species around the world have been experiencing declines in numbers and contraction of ranges for many years. Such trends are of great concern because these animals make an important contribution to ecosystems and biodiversity wherever they are present. In many cases humans have caused the changes either directly through persecution and unregulated harvesting, or indirectly through habitat destruction, pollution and the transmission of diseases. This chapter describes two species, the great crested newt and the European adder, explaining their distribution and biology in

Scotland. Emphasis is placed on the interaction of these two animals with humans with descriptions of conservation projects that have protected populations following developments.

## 2. Great crested newt

### 2.1. Scottish distribution

The great crested newt is uncommon in Scotland with a restricted, fragmented range found predominately in low-lying areas on the mainland [1] (**Figure 1**). Globally this monotypic species is present in Western Europe from Britain and southern France to southern Fennoscandia and western Russia, with Scotland at the north-west edge of its world range.

In Scotland two populations are present with largest numbers in southern parts of the country and a smaller, separate population further north in the Highlands. The species is absent from Scottish islands with the exception of a single site on Arran and an unsuccessful artificial introduction on Skye. Highest numbers are found in the south of the country from south Fife, Lothian, south Stirlingshire and Clackmannanshire through to North Lanarkshire, Glasgow and West Dunbartonshire. Other populations are found in the south-west in Dumfries & Galloway with small isolated numbers present in Perth & Kinross, Scottish Borders, Argyll & Bute and Ayrshire. The smaller Highland population with about forty breeding ponds is located around Inverness [2]. Great crested newts have also been introduced to one site further north in Highland in Caithness.

### 2.2. Habitat requirements

In Scotland the great crested newt is found at low altitudes in two broad habitat types [1] (**Figure 2**). Many of the southern sites are similar to those in England and southern continental Europe with ponds in deciduous woodland, grassland, arable areas, and post-industrial sites containing flooded pits dug for clay extraction and quarries [3–5]. However, sites in the Highlands, Perth & Kinross and some in Dumfries & Galloway and Lothian are more similar to those used by the species in northern Europe having instead native conifers, birch *Betula* spp., heather *Calluna vulgaris* and blaeberry *Vaccinium myrtillus* [6, 7].

Great crested newts populations are most productive in ponds with a combination of open water and submerged and emergent aquatic vegetation, as this allows males to find and display to prospective females during the breeding season, offers protection from predators and provides egg-laying sites [8, 9] (**Figure 3**). Breeding sites in Scotland range from small shallow ponds to some very large water bodies such as Loch Flemington in the Highlands. However, in the larger lochs newts only breed in the shallow margins where they avoid fish, which consume their eggs and larvae. The species often exists in metapopulations with breeding occurring in several ponds in close proximity joined by suitable terrestrial habitat.

In breeding ponds aquatic flora is important as eggs are laid on submerged vegetation such as willowherb *Epilobium* spp., floating sweet-grass *Glyceria fluitans*, watercress *Nasturtium officinale*, forget-me-not *Myosotis* spp. or marsh cinquefoil *Potentilla palustris* [1]. However, eggs can also be found on decomposed vegetation and even discarded refuse such as plastic bags.

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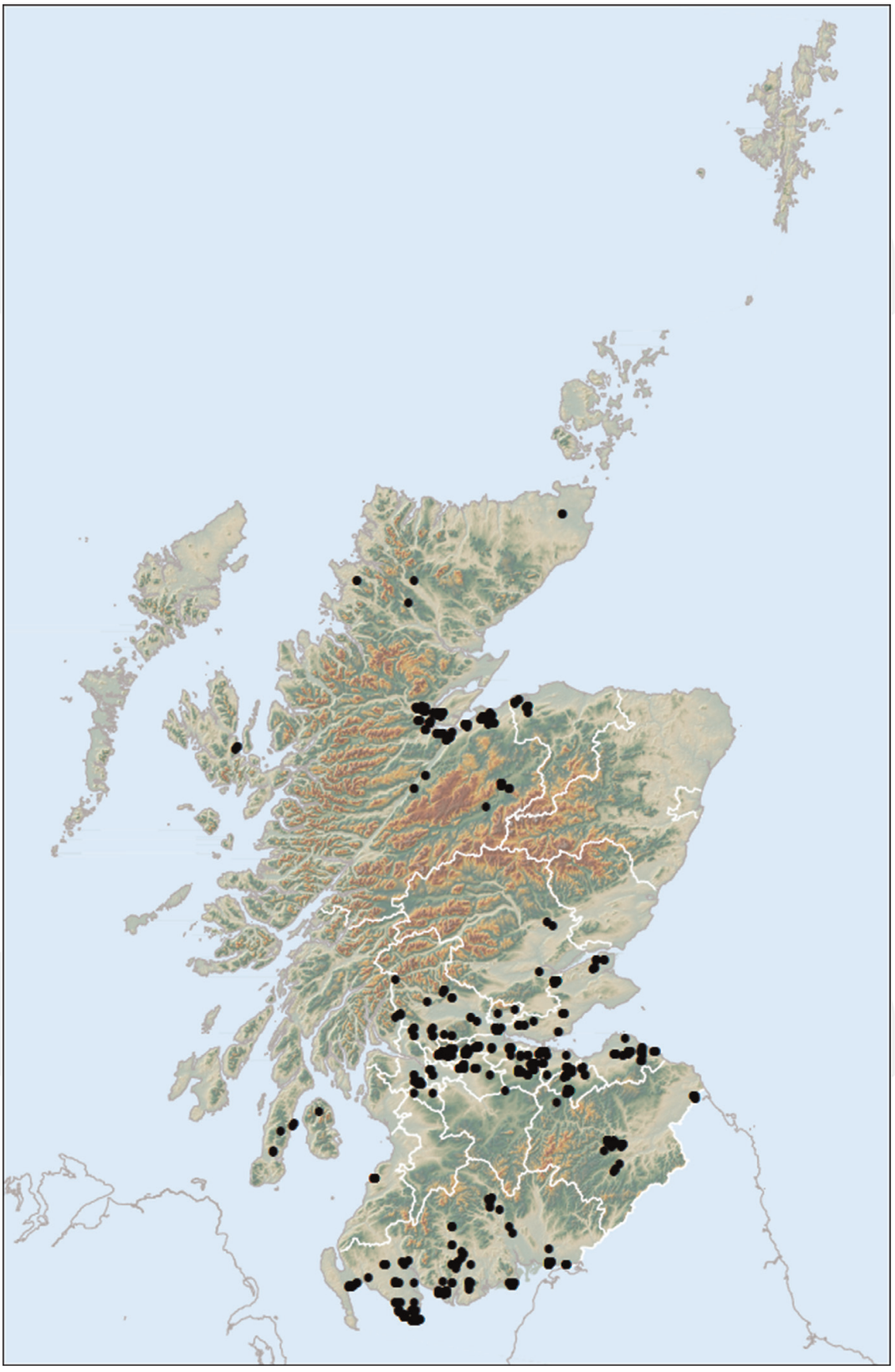

**Figure 1.** Distribution of the great crested newt *Triturus cristatus* in Scotland based on records 2000–2016. Derived from [1].

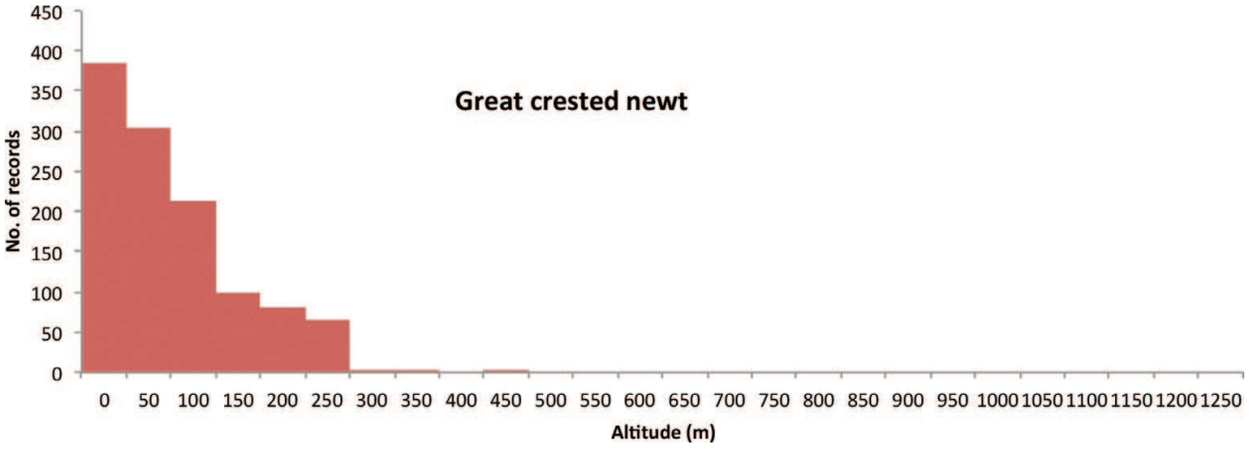


**Figure 2.** Incidence by altitude of great crested newts *Triturus cristatus* in Scotland based on records 2000–2016. Derived from [1].

**Figure 3.** A pond used by great crested newts *Triturus cristatus* for breeding at Gartcosh, North Lanarkshire, Scotland showing a combination of open water and emergent and submerged aquatic vegetation. This is one of a number of ponds created at the site to mitigate an industrial development that together hold the largest metapopulation of the species in Scotland.

The pH of water in pools and ponds influences the distribution of the great crested newt as it is usually found breeding at sites with a near neutral pH of 7.0–8.0 [4, 5]. However, in the Highlands breeding sites can have a pH as low as 4.9 but as larvae cannot develop below pH 4.5 the species is usually absent in more acidic water bodies [10].

During the aquatic phase juvenile and adult great crested newts feed on small invertebrates and larval amphibians, with tadpoles, molluscs and leeches preferred [11]. Larvae feed on

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plankton, particularly crustaceans. The terrestrial diet ranges from mites and springtails for juveniles, to worms, a wider range of arthropods and molluscs for adults.

### 2.3. Life cycle

The behaviour of the great crested newt during its annual life cycle has been studied and described [1, 5, 12].

Great crested newts hibernate through the winter usually on land with individuals hibernating under logs or rocks. They first emerge in spring from March, although most appear in April when night-time air temperatures reach about 5°C. Adults, which can live up to 15 years, are philopatric returning to ponds where they were born, mainly on warm wet nights with peak movements after midnight (**Figure 4A** and **B**). A variety of auditory cues are thought to be used to find breeding ponds such as the calls of common frogs *Rana temporaria*, common toads *Bufo bufo* and possibly wetland birds.

Males often arrive before females at ponds and occupy areas of open shallow water. Rival males defend territories mostly through visual display, so-called 'lekking', with physical contact between newts rare. The courtship by males of females involves whipping and fanning their tails, and a distinctive back arching known as the 'cat-buckle stance'. As well as visual cues the display involves the release by males of pheromones with the tail fanning transporting these to females. Females only mate after less than 10% of courtships, which is completed when a male deposits a gelatinous sperm package, called a spermatophore, with the female picking this up with her cloaca.

Fertilised eggs are then laid by the female with up to 300 eggs produced during a breeding season. Each egg is wrapped in the leaf of an aquatic plant, although eggs have also been found on discarded plastic and other materials in water. Females may use the same plant leaf to conceal more than one egg, leading to a 'concertina' effect; sometimes these are mixed with eggs of the smooth newt *Lissotriton vulgaris* or the palmate newt *L. helveticus*. The leaf wrapping both camouflages the eggs from predators and importantly shields them from ultra-violet light. Exposed eggs are vulnerable to ultra-violet light as the embryos lack the protective pigment of common frog or common toad eggs. Furthermore, up to 50% of newt embryos fail

**Figure 4.** Male (A) and female (B) great crested newts *Triturus cristatus* approaching a Scottish breeding pond. During the breeding season the male is distinguished by developing a high ragged dorsal crest that gives the species its name. The crest runs along the back ending at the base of the tail, with the tail having a separate, slightly smoother crest, which continues to the tip.

to fully develop due to developmental arrest syndrome, a genetic abnormality that affects all newt species in the genus *Triturus* [13].

The eggs hatch into larvae after 15–40 days with the length of development influenced by water temperature. Subsequent larval growth is dependent on food availability; other factors such as pollutants can retard larval growth [5]. Larvae usually metamorphose into juveniles during August or September. However, in some cooler or nutrient poor ponds larvae can overwinter in small numbers, although neotenous or paedomorphic great crested newts, where adults retain juvenile or larval traits, are very rare in Scotland [1].

After breeding many newts remain close to their breeding pond throughout the summer [14]. Adults and juveniles can be found foraging away from the breeding ponds in other shallow pools and puddles, but also on land under logs and rocks, and in vegetation [15]. Adults and juveniles can also travel further, enabling them to colonise new ponds, although the distances are limited, usually less than 1 km [16–18].

In autumn, newts hibernate underground when night-time temperatures drop below 5°C, typically from September, not reappearing until the following spring [15]. Metamorphosed juvenile newts have been shown to follow the scent trails of adults, possibly helping them to find suitable hibernation sites.

### 2.4. Scottish population and conservation

#### *2.4.1. Scottish population numbers*

The Scottish population has been estimated at between 3500 and 11,250 adults in the early twenty-first century [1, 19]. Around 200 occupied sites have been counted across the country suggesting that less than 1% of Scottish ponds are suitable for the species, with most only holding small populations [20]. However, numbers in ponds can range from fewer than ten adults to thousands as present at Gartcosh, North Lanarkshire, where the largest population in Scotland is found [21] (**Figure 3**). During a project to conserve this population, prompted by industrial development, 1012 adults were translocated in 2006, estimated to represent 9–29% of the national population at the time [19]. Subsequently, estimates of the Gartcosh population fluctuated from 100 to 515 adults with the peak count in 2015, of which 382 were males and 133 females [21]. Surveys over the period revealed a ratio of males to females ranging from 2.3:1.0 to 4.2:1.0. As the survey methods used revealed minimum estimates (6–23%) of the total population size [22] this implied that the 2015 Gartcosh population was in the range of 2239–8583 adults [21]. However, it is important to emphasise that great crested newt numbers in ponds can vary from year-to-year due to natural fluctuations as populations are thought to cycle every four years [5, 17, 23]. It has been suggested that such annual variations may be even greater in Scotland at the edge of the species' world range [24].

#### *2.4.2. Legal protection, population trends, threats and conservation*

The great crested newt is a species of international importance listed in Appendix II of the Bern Convention, Annexes II and IV of the EC Habitats Directive and classified by the International

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Union for Conservation of Nature (IUCN) Red List of Threatened Species as 'Least Concern' due to a widespread distribution, although with a decreasing population [1, 5, 25, 26]. In Britain it has shown the highest rate of decline in recent years amongst native amphibians. This trend is shared in Scotland and as a species at the edge of its world range the great crested newt might be especially vulnerable [24]. Populations are protected by both European and UK legislation [1]. In the UK legislation states that it is illegal to injure, kill, disturb, capture, keep or sell great crested newts. It is also illegal to damage or destroy the habitat in which they live. This means that where land developments threaten populations dedicated surveys are required to determine their numbers and distribution. If these surveys reveal animals, developers are then obliged to propose mitigation for newts and their habitat to qualify for a license from a government regulatory agency such as Scottish Natural Heritage (SNH) before being allowed to proceed with construction.

As the species is found predominately in low-lying areas this has brought it into conflict with urbanization, agricultural changes and industrial developments [25, 26]. For example a study in the Glasgow area found that 35% of ponds had disappeared, mainly through landfilling with waste, with 48% of those remaining vulnerable [27]. Developments can also lead to habitat fragmentation. Isolated populations are at risk of extinction and there is evidence of reduced genetic diversity at such sites in Scotland [28, 29]. However, the loss of ponds and habitat is not always caused by humans: the natural succession of vegetation can result in ponds gradually being overgrown by bushes and trees, turning habitat into wet woodland and eventually drying out. This means that at many sites habitat management is required to prevent natural succession and maintain pond suitability.

That the great crested newt often exists in metapopulations, with breeding occurring in several close ponds, is important from a conservation perspective. It suggests that the species is less likely to become locally extinct as breeding success is not dependent on a single pond [30]. However, where an assemblage of ponds exists they all require protection with the management of habitat between them equally important. An example of this is the industrial development at Scotland's largest great crested newt site at Gartcosh and efforts to mitigate for this loss by the creation of a nature reserve containing multiple ponds to where newts were translocated [21, 31]. Encouragingly, the population at Gartcosh appears to have increased following the translocation suggesting that the newly created ponds and habitat are suitable. Translocation may therefore be an effective conservation mitigation strategy for the species [17, 32].

Where agricultural chemicals are used this is likely to cause the pollution of ponds [1]. The extraction of shale gas by so-called 'fracking', where large volumes of water are injected into the ground, may lead to contamination of water bodies.

Introduced invasive non-native species are a serious problem across the species' global range. Introduced fish eat newt larvae and reduce the variety and numbers of plants and invertebrates, which are important for newts [26, 33]. Furthermore fish can inhibit newt embryonic development and spread disease [34]. There is a further risk from other non-native species such as the signal crayfish *Pacifastacus leniusculus* and American mink *Neovison vison* that predate adult and larval newts.

The chytrid fungus *Batrachochytrium dendrobatidis* has had devastating effects on amphibian populations through the world, with evidence suggesting that the disease is spread by the international trade in these animals [35, 36]. Although great crested newts do not show symptoms or increased mortality when infected by chytrid fungus they can act as carriers [37]. However, the discovery of a related *B. salamandrivorans* in fire salamanders *Salamandra salamandra* in the Netherlands is very concerning as it caused 100% mortality of infected great crested newts in laboratory tests [36].

## 3. European adder

### 3.1. Scottish distribution

The European adder is found throughout the Scottish mainland and on a few west coast islands of the Inner Hebrides, although with a fragmented distribution [1] (**Figure 5**). Globally the species is found in central and northern Europe and Asia from Britain east to the Pacific coast of Russia, with Scotland at the north-west edge of its world range. Three subspecies are recognised with the nominate subspecies *V. b. berus* present in Scotland.

In Scotland the distribution is patchy with, on the mainland, concentrations across in the north of the country from Sutherland and Caithness to Wester and Easter Ross, Aberdeenshire, Angus and Perth & Kinross; and further to the south in Argyll & Bute, West Dunbartonshire, Stirlingshire, East Lothian, Scottish Borders, south Ayrshire and Dumfries & Galloway. On islands it is present on Skye, Mull, Islay, Jura and Arran with on some islands large populations.

### 3.2. Habitat requirements

Adders are found in a wide range of habitats in Scotland with no apparent relationship between distribution and landscape, suggesting that the species is versatile in its requirements [1] (**Figure 6**). Some are found on lowland mosses, flows and upland moors. But they are also present in coastal areas and islands, at cliff sites, on escarpments, slopes and in forest clearings. Snakes are also found in more developed areas, sometimes in close proximity to humans, such as on golf courses and the embankments of roads, railways and canals, and can be very tolerant of human activity [38–40].

Habitat features used by adders in Scotland have been studied [38]. Hibernation sites, known as hibernacula, where snakes spend the winter underground, have an open southerly or westerly aspect, usually on a slope which receives large amounts of sunlight (**Figure 7**). They can also be on flat ground, if the area is well drained and free from flooding. In mosses and flows this means that they are usually on higher ground amongst rocks and the roots of trees; and on upland moors gully slopes of streams are used. Dry-stone walls can also be exploited for hibernation.

Hibernation sites are usually associated with thicker vegetation such as bramble *Rubus fruticosus* agg. or gorse *Ulex* spp. and with stands of bracken *Pteridium aquilinum,* along with

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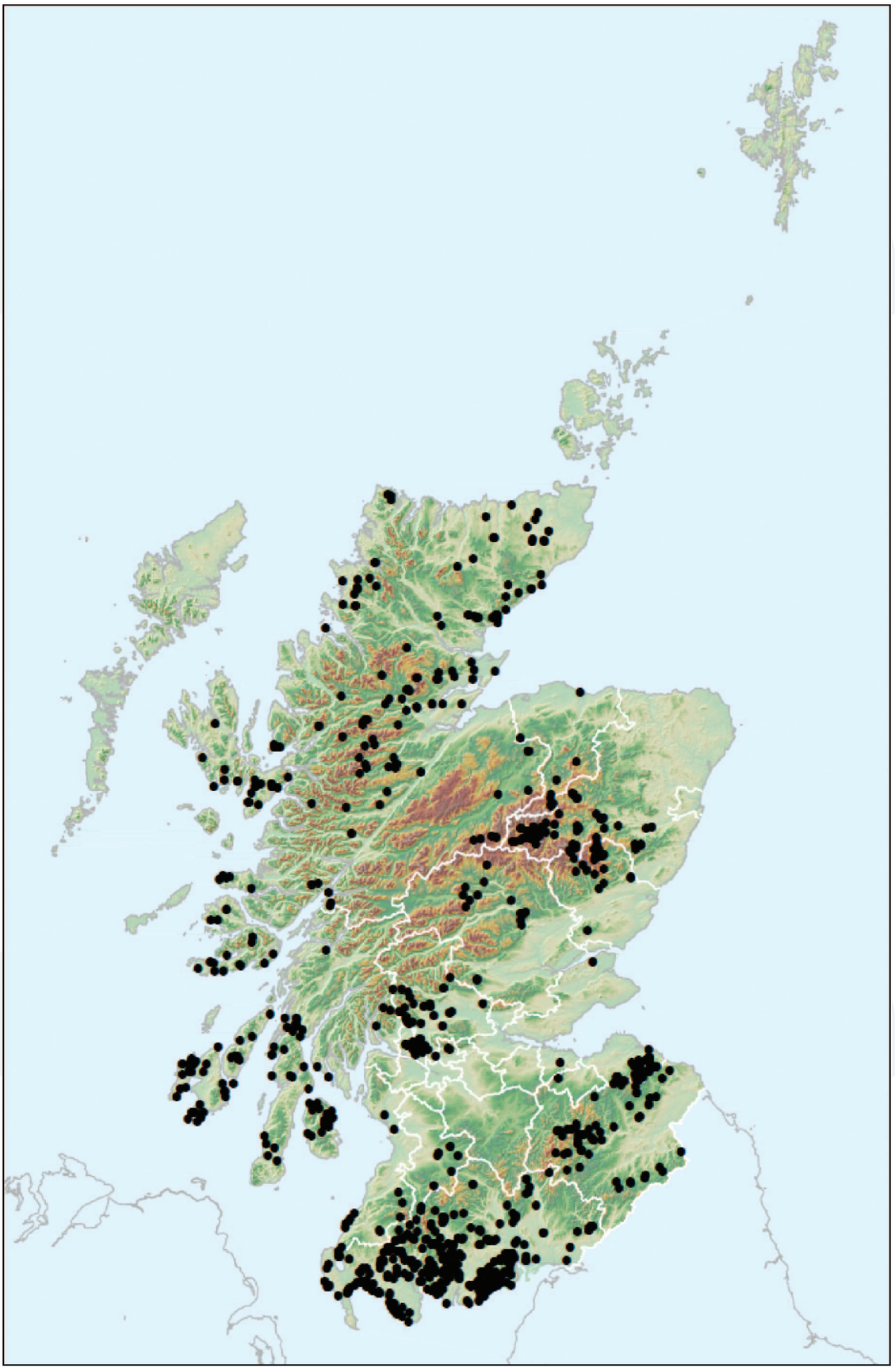

**Figure 5.** Distribution of the European adder *Vipera berus* in Scotland based on records 2000–2016. Derived from [1].

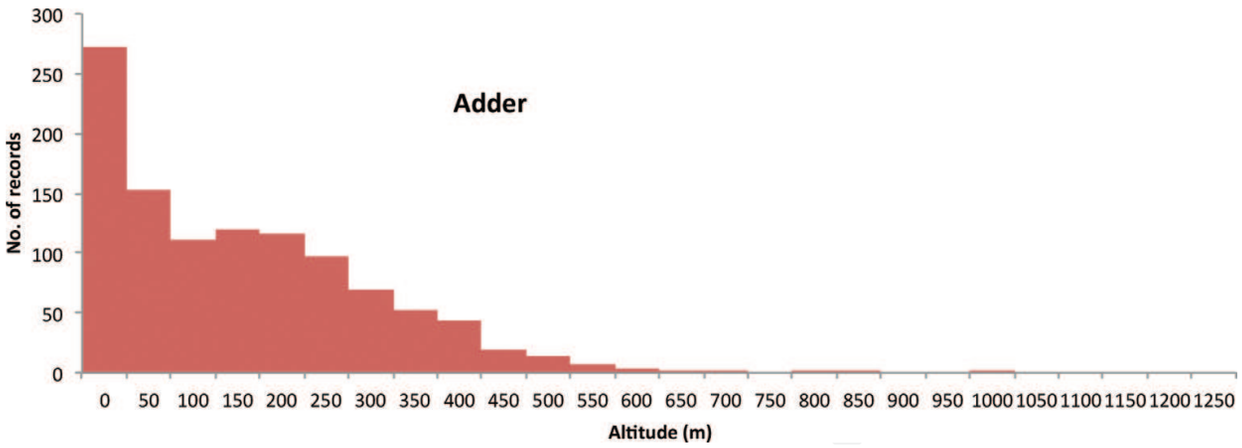


**Figure 6.** Incidence by altitude of European adders *Vipera berus* in Scotland based on records 2000–2016. Derived from [1].

**Figure 7.** European adder *Vipera berus* hibernation site at Loch Lomond, Stirlingshire, Scotland. The hibernaculum, where snakes spend the winter underground, has an open southerly aspect on a slope with patches of moss and thicker vegetation such as gorse *Ulex* spp. and stands of bracken *Pteridium aquilinum*. These provide areas for adders to bask in the sun and the opportunity to retreat to safety after disturbance.

patches of moss and grass. Snakes often bask in the sun on moss or grass and use the thorns and spikes of nearby bramble and gorse as protection under which to retreat when disturbed. Bracken appears to be an important habitat component in Scotland as adders are often found near it, with the bracken providing hibernation sites, protection and a warm microclimate [1, 40]. In winter, flattened bracken forms mats that provide insulation to hibernating snakes from cool temperatures. In summer, stands of bracken create sheltered, sunny areas. Adders are very well camouflaged when inhabiting bracken and the association of the species with bracken may explain its zigzag markings, which look very similar to dark brown bracken leaves. Similarly, the chestnut brown colour of juvenile adders is almost identical to bracken leaves in late summer, autumn and early spring. However, an alternative explanation for the zigzag is that it is a warning sign to discourage predators [41, 42].

Habitat near to hibernation areas is important, often containing wet or marshy ground, ponds and streams. This may be because such wet areas are a source of food items. Adders consume a

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range of prey including adult and young amphibians, reptiles, birds and small mammals [1, 43–47].

### 3.3. Life cycle

The behaviour of the adder during its annual life cycle has been studied and described [1, 48–50]. In Scotland a population of adders has been monitored on the shores of Loch Lomond, Stirlingshire with seasonal changes in behaviour recorded similar to those observed elsewhere in the UK and continental Europe [40, 51].

Adders hibernate through the winter at underground sites, males first emerging on sunny days in mid-February, with more males and females appearing in March. At Loch Lomond many snakes hibernate by themselves, although more rarely groups of up to four have been observed [40, 51]. Adders remain near to hibernacula, emerging and basking for extended periods in the cooler temperatures until mid-April when, in warmer conditions, they shed skins (ecdysis) and initiate courtship and mating (**Figure 8A** and **B**).

Adders can use the same hibernation and basking sites both within years and between years, and even throughout their lifetime, which can be up to 30 years [1, 50]. Individuals usually first emerge to bask in the morning sun, but later if conditions are not favourable. They then bask for 1–2 hours, often on sunny patches of moss or grass next to areas of bracken, gorse or bramble, before moving to cover, having warmed up. If disturbed they retreat to cover either underground or into the bracken, gorse or bramble, typically reappearing after a few minutes. Individuals sometimes 'mosaic bask' whereby they expose only parts of their body to sunlight to warm up while remaining camouflaged and thus hidden from predators.


**Figure 8.** Male (A) and female (B) European adders *Vipera berus* recovering in the Scottish spring after hibernation, having shed their skins. The male is distinguished by having a grey background skin colour and black edges to snout scales, whereas instead the female is brown with pale edges to snout scales.

In Scotland adders will attempt to bask on cloudy days, when the sun shines only for short periods, even if the air temperature is only just above freezing or when frost or snow is present. On first emergence they lie fully extended flattening their bodies, probably to maximise absorbance of solar energy. If conditions cool, snakes will coil to retain body heat, eventually retreating underground, only re-emerging if conditions improve. On such inclement days, basking by snakes can be interrupted and so last many hours.

Courtship and mating occur from middle April to early May when air temperatures increase and after females shed their skins. Recently shed males locate females by following their pheromone trails. If a male encounters another male who is also searching for a female, they can participate in a wrestling match described as the 'dance of the adders'. This can last from a few seconds to many minutes with the dominant male chasing off the rival. When a male finds a receptive female he initiates courtship by coiling, head-bobbing and licking, which lasts 1–2 hours. Mating follows a distinctive joint tail arching and also lasts 1–2 hours. After mating, males usually guard females to prevent them associating with other partners. Even so, females have been shown to mate with multiple partners in the same breeding season [52, 53].

Following the mating period males and unmated females move to other areas to feed [54]. Mated gravid females instead remain near to their hibernaculum, or find another sunny area nearby, where they bask for extended periods as this accelerates the growth of the developing young [55]. For the same reason they are sometimes found basking coiled with other female adders or with gravid slow-worms *Anguis fragilis*, likely to share body heat [40, 49]. Adders are viviparous giving birth to up to 13 live young, although the usual range is 4–10. Live-bearing reptiles are more common in colder climates, such as Scotland, where the young require the mother's warmth to develop. In contrast, many reptile species which inhabit warmer climates are able to lay eggs because ambient temperatures are high and constant enough for egg development. Gravid females are not thought to eat while carrying developing young and reproduction is physiologically stressful. This results in females usually not breeding every year [56, 57].

In Scotland young adders first appear from early August, but can be found up to late October and also sometimes in early spring immediately after hibernation. Young receive no parental support, surviving on a yolk supply within their body until prey is found which, if they are born late in the year, might not be until the following spring after hibernation. Female adders, after giving birth, feed and recover before hibernation; even so, mortality is higher for females in winters following birth [56, 57].

Adders undergo ecdysis shedding their skin from first emergence in early spring to late autumn, although it is most noticeable in April and May when snakes with fresh skin show the most vivid colours in preparation for mating (**Figure 8A** and **B**). Ecdysis in spring, late summer and early autumn appears to encourage males to follow females, but it is not known if successful mating occurs at later times of the year.

Adders return to hibernation sites from September and can bask until late October or even early November when hibernation begins. Animals occasionally emerge through the winter if it is sunny and mild. Adders have been noted hibernating underground alongside slow-worms, common toads and common lizards.

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Adders have been observed showing striking synchronicity of behaviour at different times of the year both between individuals at a single site and between individuals at different nearby sites. For example, emergence from hibernation, skin-shedding, courtship and mating have each been noted to occur on the same day at different sites around Loch Lomond [1].

### 3.4. Scottish population and conservation

#### *3.4.1. Scottish population numbers*

Adder population numbers across Scotland have not been estimated although in the early twenty-first century some parts of the country hold high densities in suitable habitat where the species is not persecuted [1].

A few local Scottish population estimates have been made. In the late nineteenth century '40 per acre', equivalent to about 100 per hectare, were recorded on a lowland moss near Dumfries with a total population of 2400 [43]. More recently at a Loch Lomond site, which consists largely of native replanted forest, over 200 individuals were recorded in an area of six hectares over four years: during this period estimated population densities varied from 62 per hectare in 2012, to 236 per hectare in 2014 [40]. Furthermore, based on counts of individuals, the ratio of males to females varied between years, from 1.0:1.6 to 1.3:1.0, with an average during the period of 1.0:1.1, suggesting that similar numbers of the two genders were present [40]. At another site in Scotland, a lowland golf course, over 54 individuals were counted within four hectares over five years [58].

#### *3.4.2. Legal protection, population trends, threats and conservation*

The European adder is a species of international importance listed in Appendix III of the Bern Convention and classified by the IUCN Red List of Threatened Species as 'Least Concern' due to its widespread distribution, although with a decreasing population [1]. In Britain populations have shown declines in recent years [59]. Adders are protected by both European and UK legislation [1]. In the UK legislation states that it is illegal to injure, kill or sell animals.

In Scotland man is the most serious threat to the adder, both directly through persecution and indirectly by habitat loss [59–61]. Venomous snakes, such as the adder, have a long history of being misunderstood, feared and mistreated. To this day, despite legal protection, animals are still mistreated and killed.

Habitat loss is a problem, although many seemingly suitable areas remain in the country [1, 38, 62]. Adders have disappeared from many sites as a result of management practices such as drainage, muir-burning and afforestation. For example the conversion of moors to commercial forests is likely to have reduced adder numbers and distribution as this creates less suitable habitat for these reptiles. Similarly, the restoration of mosses, flows and peatlands can have negative impacts through the loss of hibernation sites if water levels are raised and appropriate mitigation is not put in place.

On a more positive note adders can be very tolerant of humans and human developments, if they are considered and suitable protection and precautions are put in place. This is illustrated

by the site at Loch Lomond where high densities of snakes are present, some very close to human habitation [40]. Here a small hydroelectric scheme was installed with the development crossing through an area with the highest reptile densities [39]. The implementation of a mitigation plan to both move and protect the reptiles, the monitoring of adder numbers before and after the development, and the observation of snakes mating and giving birth close to the site during construction, together suggested that the population was unaffected by the development. Similarly, adders have been shown to prosper on a Scottish golf course where the habitat and management regime has allowed them to co-exist with golfers [58].

## 4. Conclusions

This chapter has described the distribution and life cycle of two species of amphibian and reptile in Scotland, the great crested newt and the European adder. In both cases examples of conservation projects are outlined that mitigated the effects of human development projects on local populations which appear to have been successful. Such work demonstrates that amphibians, reptiles and humans can co-exist to the benefit of both. This suggests that a wider understanding and appreciation of these wonderful creatures will encourage and increase this relationship in the future.

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