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Action Plan for the Conservation of the Aesculapian Snake (*Zamenis longissimus*) in Europe

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SUMMARY

The Aesculapian snake is a large, harmless species that has suffered declines in a number of countries in Europe. This Action Plan has been commissioned by the Standing Committee of the Bern Convention in order to assess the extent of the problems faced by this species and to make appropriate recommendations to address these. It should be noted that recent taxonomic work has resulted in a change in the scientific name of the Aesculapian snake from *Elaphe longissima*, which has previously been used in all Council of Europe and European Union documentation, to *Zamenis longissimus*. In addition, former subspecies of this snake found in southern Italy, the Greek Cyclades islands and southeast Azerbaijan have now been elevated to full species status and are therefore disregarded in this Action Plan.

Zamenis longissimus is a relatively slender snake that can reach 2.25 m in total length, but is more usually around 1.4–1.6 m. Adult Aesculapian snakes are a fairly plain brown, yellowish or olive colour and the anterior third of the body is often distinctly lighter. Various white spots and vague longitudinal stripes may also be present. Juveniles are much more boldly marked and somewhat resemble grass snakes, *Natrix natrix*. The Aesculapian snake is found from sea level to 2,000 m in a variety of habitats, including deciduous woodland, scrub, marshy areas, traditional farming landscapes and around human dwellings. These snakes seem to prefer humid regions and are often associated with river valleys. They are excellent climbers and it is becoming apparent that they utilise the interior and the canopy of woodlands far more than previously thought. Aesculapian snakes are powerful constrictors and prey on small rodents, making them economically beneficial to farmers, as well as on birds and lizards.

Although a diurnal species it is secretive and seldom seen. The optimum shade temperature for activity appears to be between 16 and 25 ^{o}C. The average home range in France was calculated at 1.14ha, although males can travel 2 km or more while searching for a mate and females make similar journeys to locate suitable egg laying sites. Mating Aesculapian snakes perform an elegant "dance" with their front ends raised in an S-shape and the bodies and tails intertwined, the behaviour that is represented on the international medical symbol. An average of 5-11 eggs are laid in some form of decomposing vegetation, such as heaps of leaf litter, compost and manure or humus-filled holes in trees, and many females may utilise the same site if it is particularly favourable for incubation. Juveniles vary from 12-37 cm in length and are fully self-sufficient upon hatching. Aesculapian snakes have numerous predators, especially when young, including many mammals and birds, but do not appear to have many direct competitors among other snakes.

Zamenis longissimus has a wide distribution, occurring in 26 countries in geographical Europe with just one separate population, around Lake Urmia in northern Iran, outside the Council of Europe area. This species has been lost from one country, Denmark, where a relict population, well north of the main range, is thought to have become extinct in the late 19th Century. Several other isolated populations are still found around the edges of the current range and are thought to be remnants of a former, much wider distribution, dating back about 5,000 years when the climate was warmer. These populations are now confined to areas with particularly favourable microclimates and are of most conservation concern for this species. Countries where such naturally isolated populations are found include:

Germany. Three isolated populations of *Zamenis longissimus* occur around Hirschhorn in the Neckar-Odenwald region (Hessen and Baden-Württemberg), in the Schlangenbad/Wiesbaden Rheingau-Taunus area (Hessen) and in the Salzach Valley (southern Bavaria). A fourth population, near Passau (southeast Bavaria), is continuous with the main European distribution.

Poland. Three isolated populations occur in the provinces of Czestochowa, Nowy Sacz and Zamosc. A further population in Krosno, in southeast Poland, is connected to the main area of distribution.

Czech Republic. Isolated populations exist near Karlovy Vary (Carlsbad) in Bohemia and at Valasske Klobouky. A population on the Dyje River in southern Moravia is connected to the main distribution.

Italy (Sardinia). There are a few records of this species from western Sardinia although its current status here is unknown.

Turkey. An isolated population occurs on the northern slopes of Mount Ararat in eastern Turkey. Aesculapian snakes are also found in northeast Turkey where they form part of the population along the eastern shores of the Black Sea, extending into Georgia and southern Russia, which is itself separate from the main European distribution. This species is also found in northwest Turkey, where it is connected to the main European distribution via the Greek and Bulgarian populations.

Georgia. One apparently isolated population occurs in the northeast corner of the country, near Lagodekhi. The Aesculapian snake is also widely distributed in the western half of Georgia along the Black Sea coast and up into the foothills of the Caucasus Mountains.

Russia. This species is found in southern Russia along the Black Sea coast and at the western end of the Caucasus, where its distribution is connected to the populations in Georgia and Turkey. However, an isolated population is reported to occur further inland, west of the city of Stavropol.

The conservation status of the Aesculapian snake is largely unknown throughout its range. While it has clearly declined in some countries, because of direct habitat loss and other threats, it is often considered to be a naturally rare species anyway. However, this is a very elusive snake, which is difficult to monitor effectively, so its perceived rarity in some countries may simply be due to insufficient survey effort. As well as potentially being more abundant at some locations than previously thought, this species may also be present where it is believed to be absent. It was once thought that a naturally isolated population of *Zamenis longissimus* was present in western Ukraine, for example, although this locality now appears to be connected to the main European range.

Nonetheless, numerous Aesculapian snake populations, even within the main range, have now become effectively isolated by habitat destruction and fragmentation. The clear felling of deciduous woodlands, to make way for intensive agriculture, conifer plantations and urban development, has been a particularly serious problem in many countries. The traffic on busy roads can take a particularly heavy toll on any males or gravid females that cross them while making long distance movements. The increasing mechanisation of forestry and farming has adversely affected many populations and the removal of ancient trees, used for shelter, foraging and egg laying, has also been cited as a problem. Other threats to this species include persecution, illegal collection, pollution and overgrazing. Although little international funding has been available for the conservation of *Zamenis longissimus*, several individual countries have carried out work specifically for this species, especially northern range states such as Germany, Czech Republic and Poland.

The overall goal of this Action Plan is to expand on these successes and ensure the maintenance, and restoration where necessary, of viable populations of Aesculapian snakes across Europe – with a particular focus on the isolated, range-edge populations. A series of general objectives are outlined and specific actions are proposed here that include the improvement of international liaison and coordination of conservation efforts for this species, additional distribution surveys, habitat management recommendations, population and conservation status monitoring, scientific research and public awareness programmes.

1. INTRODUCTION

Although the Aesculapian snake, *Zamenis longissimus*, is widely distributed in Europe, it is rarely considered to abundant and also appears to be declining in numbers. Several isolated populations are found around the edges of the current range and are thought to be remnants of a former, much wider distribution. While these isolated populations are under the most threat, and are therefore the focus of several actions proposed in this plan, populations within the main distribution also face many problems. The Aesculapian snake is a harmless species that, due to its rodent eating habits, is beneficial to humans. Apart from its important ecological role, it also has symbolic and cultural interest in Europe, and is the snake represented on the international medical symbol (see cover).

An attempt has been made in this Action Plan to summarise the literature that is most pertinent to Aesculapian snake conservation. The taxonomy and ecology of this species are covered briefly, while more attention is given to its distribution and status and to the threats that it is known to face. A series of general objectives and specific conservation actions are recommended for adoption by the Bern Convention and relevant national governments. It should be noted that this Action Plan is not intended to be a static document. As additional information is obtained, and as conservation work and scientific research progress, subsequent versions should be produced that report on successes and

make updated recommendations as required. In future years, the successful conservation of the Aesculapian snake should be seen as an important measure of, and contribution towards, international efforts to maintain the biodiversity of Europe.

2. BACKGROUND INFORMATION

2.1. Systematics

The Aesculapian snake was first described by Laurenti (1768) as *Natrix longissima*. Different populations of this snake have since been described under a variety of names; with the generic name *Zamenis* first being used in 1841. However, all Bern Convention and European Union documentation, and most published papers, refer to this snake as *Elaphe longissima*, which was the recognised scientific name for this species from 1926 until 2002. Nonetheless, this taxonomic placement had long been considered unsatisfactory as the genus *Elaphe* was obviously paraphyletic and overdue for revision. This situation was only resolved when the latest DNA research (Utiger *et al* 2002) produced a phylogeny that now places the Aesculapian snake back into the genus *Zamenis*, in which the specific name reverts to the masculine form *longissimus*. The Aesculapian snake is now considered to be a monophyletic species and so the former nominate subspecies *Elaphe longissima longissima* becomes simply *Zamenis longissimus*. The three other subspecies of *Elaphe longissima* described in the past have now been raised to full species status and are therefore disregarded in this Action Plan. These are:

Elaphe longissima persica. Found in sub-tropical forests in northwestern Iran and Talysh, southeast Azerbaijan. Now known as *Zamenis persicus*. Reference: Szczerbak (2003).

Elaphe longissima reichingeri (Synonym: *Elaphe reichingeri*). From the Cyclades Islands, Greece, especially Amorgos. Now known as *Elaphe quatuorlineata muenteri*. Reference: Schultz (1996).

Elaphe longissima romana. Sicily and southern Italy, north to Matese. Now known as *Zamenis lineatus*. Reference: Lenk and Wüster (1999).

2.2. Description

2.2.1. Morphology. *Zamenis longissimus* is a medium to large, relatively slender bodied snake, normally attaining a total length of 1.4 –1.6 m. Large adults from southern Europe can reach a maximum length of 2.25 m, but rarely exceed 1.8 m in the north of the range. The tail is long and tapering and can be as much as 20-25 % of the total length. Male Aesculapian snakes grow significantly longer than females. The maximum weight for this species in Germany is about 890g for male snakes and 550g for females (Böhme 1993; Gomille 2002). The head is long, slender and not very well defined from the neck. The eye is moderate in size with a round pupil. Although the dorsal scales on the anterior third of the body are smooth, they are lightly keeled on the posterior two thirds. The ventral scales are sharply angled where the underside meets the body, which enhances this species' climbing ability. The arrangement of the scales includes 23 scale rows at mid body, rarely 21 or 19, 211-250 ventral scales, a divided anal scale and 60-91 paired subcaudal scales (Schultz 1996; Arnold 2002).

2.2.2. Colouration. There is no noticeable sexual dimorphism in the colouration of *Zamenis longissimus*. Adults are a fairly uniform grey-brown, yellow-brown or olive and the anterior part of the body is usually noticeably lighter. Some dorsal scales may be edged in white and these scales may occur in bands. This is more obvious when the animal has recently fed and the body is distended. Some specimens may have indistinct stripes along the body, especially in Italy, and these can be either light or dark (Arnold 2002). The scales of the upper jaw region are usually yellow and there are often two yellow patches at the back of the head, somewhat reminiscent of the collar of the grass snake *Natrix natrix*. The ventral surface is yellow or whitish and may be marked with a few grey spots in some individuals. Juveniles are much brighter in colour than adults and have four to seven rows of brown spots along the body. The yellow markings at the back of the head are also very distinct. A dark stripe runs backwards from each eye to the back of the jaw and another runs from the centre of each eye down to the lower jaw. There is a also a dark line on the top of the head of juveniles, just in front of the eyes. Both melanistic and albino forms of Aesculapian snake have been recorded and a

dark grey form, var. *subgrisea* (Werner 1897), is known from the Zemplén area of northern Hungary as well as from the island of Krk, off the Istrian Peninsula of Croatia (Schultz 1996).

2.3. Life History

2.3.1. Habitat Requirements. The wide distribution of this species across Europe means that habitats occupied can vary with the local climate and altitude. *Zamenis longissimus* is found from sea level to about 2,000 m (Arnold 2002) in open, deciduous woodlands, scrubby areas and along hedgerows in traditional farming landscapes. It also frequents rocky areas or overgrown fields where there are plenty of dry stone walls or ruined buildings. This species appears to prefer humid regions and is often associated with river valleys. For example, the northernmost populations particularly favour the south facing slopes of hills or mountain ranges that descend into river valleys (Gomille 2002). In addition, although they were once thought to only frequent sunny forest edges and other open habitats in the north, these snakes are now known to utilise the more shaded and humid forests here, as they do further south. Indeed in France *Zamenis longissimus* is the only species of snake known to inhabit the interior of forests where hardly any ground vegetation is present (Doré 1986), presumably because it is utilising the tree canopy. According to Street (1979), this species avoids very marshy habitats, although they have been found in reed beds in Hungary (Schmidt 1976) and Croatia (Z. Tadić *pers. com.*), as well as in delta areas in Greece (Kordges and Hemmer 1987). This species tolerates the presence of humans, often living around villages and other rural developments and frequently entering houses and sheds, especially on cool days (Heimes 1991). Aesculapian snakes have even been encountered in parks and gardens in some urban areas, for example in the city of Wiesbaden, Germany.

The Aesculapian snake is an excellent climber and is even capable of ascending vertical, branchless tree trunks. This species has been observed at heights of 4-5 m in trees (but will presumably climb higher) and foraging in the roofs of buildings. It is also known to make use of cavities in trees for shelter and as egg laying sites (Vogel 1968). It is not known what proportion of its time is spent arboreally, rather than on the ground, but it is possible that this may be substantial in some areas or at certain times of the year, when birds are nesting for example. Consequently, the frequency of sightings of this snake may be misleadingly low.

2.3.2. Dietary Requirements. Aesculapian snakes predominantly feed on small rodents, such as voles, mice, rats and even squirrels, as well as birds, eggs and nestlings (Luiselli and Angelici 1996; Arnold 2002). The young are known to prey on lizards as well as small rodents. This species is non-venomous but is a powerful constrictor, preventing its victims from breathing with strong contractions of its coils, thus killing them by suffocation.

2.3.3. Activity and Movements. *Zamenis longissimus* is a diurnal snake but is sometimes active in the evenings in hot weather. Although it will bask when necessary, it is fairly secretive and keeps close to shelter most of the time. Peak activity has been recorded as "early morning" and between 16:00 and 19:00 (Beshkov 1976). The optimum temperature for activity in German populations is 20-22°C (Heimes 1988) and they are rarely recorded when the temperature is below 16°C or above 25 °C. The length of the hibernation period depends on the locality. In the south of the range this usually starts in October, with the snakes emerging in March. Northern populations enter hibernation slightly earlier and come out slightly later. Hibernation sites known to be utilised include crevices in rocks, holes in trees and old haystacks. Aesculapian snakes exhibit a degree of activity while hibernating, moving around to maintain a body temperature of approximately 5°C and occasionally emerging to bask on warm sunny days (Naulleau 1994). The average home range of this species in France has been calculated at 1.14 ha (Naulleau & Bonnet 1995). However, males will move up to 2 km to find females during the breeding season and gravid females may also travel considerable distances to find suitable egg laying sites.

2.3.4. Reproduction. The Aesculapian snake breeds annually, with some 77% of adult females reproducing each year (Naulleau & Bonnet 1995). Males of less than 74 cm in length and females under 85 cm have not been observed taking part in breeding activity (Naulleau 1992). Mating usually occurs from mid-May to mid-June. Rival males indulge in combat bouts, although these are generally trials of strength, with each snake attempting to pin down the other without any serious biting. Courtship between males and females involves an elegant dance, with the anterior portions of the bodies raised in a S-shape and the tails entwined. The male will also grasp the female's head with its

jaw (Lotze 1975). In late June or July, the female lays 2-18 elongate eggs (average 5-11) that each measure up to 60 x 25 mm, in a some type of decomposing vegetation (Capizzi *et al* 1996; Arnold 2002). Sites chosen for egg-laying include compost or manure heaps, saw mill waste, piles of leaf litter, old tree stumps, humus filled cavities in tress and old hay stacks. Many females will utilise a particularly good site and they often share these with grass snakes, *Natrix natrix*. Over 2,000 eggs of both species were found in a single manure heap in Hessen, Germany (Golder 1985). Aesculapian snake eggs usually hatch at the end of August or in early September. The hatchlings can vary enormously in size from 12-37 cm (Arnold 2002), are born fully independent and normally enter hibernation a few weeks after the adults.

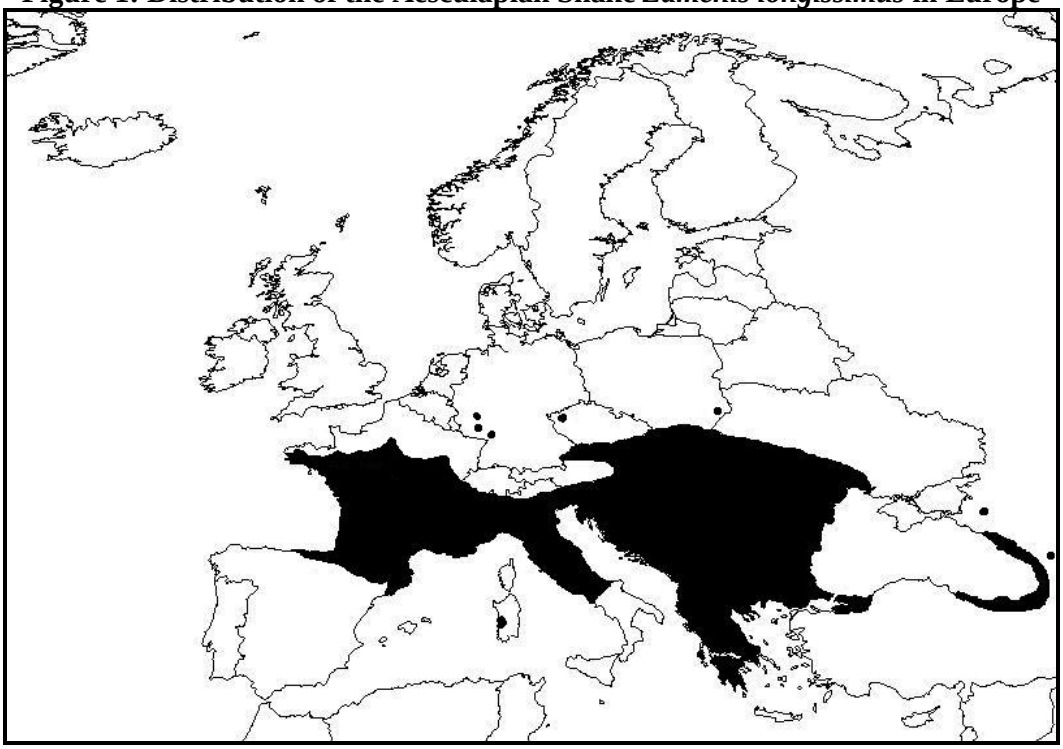
2.3.5. Predators and Competitors. Aesculapian snakes are preyed on by a variety of mammals and birds. Known predators include badgers and other mustelids, foxes, wild boar, hedgehogs and various birds of prey. Smooth snakes, *Coronella austriaca*, will also consume juvenile Aesculapian snakes. This species does not seem to compete directly with any other snake species in France (Doré 1986).

2.4. Distribution and Conservation Status

2.4.1. Summary of the Distribution and Conservation Status of the Aesculapian Snake

The Aesculapian snake has an extensive range in Europe (Figure 1; Gasc *et al* 1997). It has been postulated that the patchy distribution of this species in northern Europe, especially the isolated populations that occur close to thermal springs (for example at Schlangenbad, Germany), is the result of deliberate introductions by the Romans. In fact, these isolated northern populations are much more likely to be the remnants of a past wider distribution from a time when the climate was warmer around 5,000 years ago (Boulenger 1913; Ljungar 1995; Holman 1994; 1998). Evidence for the latter theory comes from the fossil remains of this snake, and other thermophilous species, that have been found in parts of Germany, Poland, Denmark and the United Kingdom. In addition, the Romans are not known to have actually occupied some of the northernmost localities where Aesculapian snakes survive today. Outside geographical Europe, *Zamenis longissimus* also occurs in northern Iran. An introduced population in the United Kingdom still survives in north Wales. This species exhibits very little genetic diversity throughout its range (Jöger *et al* 2004).

Figure 1: Distribution of the Aesculapian Snake *Zamenis longissimus* in Europe



The overall conservation status of *Zamenis longissimus* is only partially known at present but it is recognised as a "Species of Special European Concern" (Council of Europe 1997). The modern stronghold of the Aesculapian snake is clearly central and southern Europe and these snakes can still be widespread and abundant in some areas here. However, the conservation status of this species appears to vary considerably from country to country and is probably unfavourable for Europe as a whole.

2.4.2. Distribution of the Aesculapian Snake in its Main European Range

Spain. Confined to northern Spain along the foothills of the Pyrenees, roughly north of a line from Santander to Barcelona (Salvador 1974; Bea *et al* 1978; Mellado *et al* 1979; Gasc *et a*l 1997), where it has suffered some decline (Blanco & González 1992).

France. Widespread in France, with the northern limit in Brittany (Julien 1988; Naulleau 1989b). Records for this species are scattered but the main areas of distribution are in northwest, east and southeast France.

Switzerland. The Aesculapian snake occurs in south and southwest Switzerland in the Cantons of Vaud (Rhone Valley), Genf, Graubünden, Valais and lower Tessin. This species is found up to an altitude of 1600 m in Valais. Has become extinct west of Lake Neuchatel and at Biel and Walen See.

Italy. Widespread throughout northern and central Italy down to an area just north of Matese. Filippi & Luiselli (2000) used various factors to assess conservation threats to the Italian snake fauna and the Aesculapian snake was considered to Vulnerable, although not actually threatened.

Slovakia. Occurs in southern and eastern Slovakia, mainly in hilly regions but also in the lowlands near Gabcikovo and Rusovce. The northernmost localities, which this snake reaches via river valleys from the south, are the Muranska plateau and the Uzska highlands (Barus and Oliva 1992; Rehák 1992).

Austria. Mainly occurs in central and eastern Austria, and is quite abundant in the Danube, Drau and Mur valleys, but is very rare in the western states. Populations have been isoltaed by habitat fragmentation in North Tyrol and West Salzburg (Council of Europe 2003b) and there has been a notable decrease in the abundance of this species in Carinthia (Grillitsch and Cabela 1992)

Hungary. *Zamenis longissimus* is widespread but localised here and is most abundant in the forests and mountain regions of western Hungary and the Körös Valley in the east of the country.

Romania. The Aesculapian snake has a patchy distribution in Romania. A grave decline of this species, due to habitat destruction and pollution, has been reported for Romania, with some populations having become extinct (Council of Europe 2003a). Some areas of Romania still appear to support good populations while others, with seemingly similar habitats, are devoid of this snake (I. Ghira *pers. com.*). However, more surveys are required to clarify the distribution and status of this species in Romania – for example, the Aesculapian snake was only recently discovered in southern Dobruja (Andrei 2002).

Republic of Moldova. Widely distributed throughout the country with a strong population on terrace steps of the lower Dniester. However, it is listed as Endangered in the Moldovan Red Date Book.

Ukraine. Occurs in western Ukraine in the River Bug and Dniester areas, in beech forests on the north slope of the Carpathians and on the sheltered south slope of the Kuzyisyi massif. Once thought to be a naturally isolated here, this species actually appears to be linked, via populations in the Republic of Moldova, to the main European distribution (see Gomille 2002). However, the southern Bug and Carpathian populations have suffered extensively from habitat fragmentation (Council of Europe 2003b). The Aesculapian snake is listed as Endangered in the Ukrainian Red Data Book.

Bulgaria. The Aesculapian snake is commonly encountered throughout Bulgaria but is under threat in some areas from forest clearance and farming. Included in the national Red Data Book (Beshkov 1985).

Slovenia. Widely distributed over the whole country (Vogrin 1997). However, as this species appears to be declining in Slovenia it is listed as Vulnerable in the national Red Data Book (Mrsic 1992).

Croatia. Widely distributed on in Croatia, including the islands of Rab, Solta, Brac, Hvar and Mljet.

Serbia. Widely distributed throughout the country.

Bosnia-Herzegovina. Widely distributed throughout the country.

Montenegro. Widely distributed throughout the country.

Albania. Widely distributed throughout the country.

Former Yugoslavian Republic of Macedonia. Widely distributed throughout the country.

Greece. Only scattered records for this species exist across mainland Greece. They are encountered most frequently in forests in northeast Greece but are also known elsewhere on the mainland, including some estuary habitats (Kordges and Hemmer 1987) and a few sites in the Peloponnese (Chondropoulos 1989). The only islands where this snake has been recorded are Paxos and Corfu (Wütschert 1984).

2.4.3. Distribution of the Aesculapian Snake outside its Main European Range.

Denmark. *Zamenis longissimus* was reportedly common near Copenhagen in the late 1700's (Boulenger 1913) and apparently persisted until about 1863, but is now extinct in Denmark.

Germany. Populations of Aesculapian snakes are found at Hirschhorn in the Neckar-Odenwald region (Hessen and Baden-Württemberg), in the Schlangenbad/Wiesbaden/Rheingau-Taunus area (Hessen), the Salzach Valley (southern Bavaria) and near Passau in southeast Bavaria (Klemmer 1985; Drobny 1993; Gruschwitz *et al* 1993; Gunther and Waitzmann 1996; Gomille 2002). The first three populations are isolated while the fourth is continuous with the Austrian population. This species was also introduced to Schlitz (Upper Hessen) around 1853 (Jaeschke 1971) but has since become extinct here (Waitzmann 1989; Heimes 1990). New urban and road developments around Wiesbaden threaten some of the habitats inhabited by the Rheingau population (Council of Europe 2003a).

Poland. Three isolated populations occur in the provinces of Czestochowa, Nowy Sacz and Zamosc (Budziszewski and Zemanek 1978; Szyndlor 1984; Najbar 1986; 2000b). The habitat of the largest population, found in the San River corridor north of the Bieszczady National Park, has been protected as a species reserve (Najbar 2000a). A further population in Krosno, in the southeast of the country, is connected to the main area of distribution in Europe.

Czech Republic. The Aesculapian snake is considered to be critically endangered in the Czech Republic (Necas *et al* 1997). Isolated populations exist near Karlovy Vary (Carlsbad) in Bohemia and at Valasske Klobouky (Barus and Oliva 1992; Rehák 1992). The isolated populations in west Bohemia decreased rapidly in the second half of the 20th Century but this decline seems to have stopped. These populations have been successfully protected and are now under conservation management (Necas *et al* 1997). A population on the Dyje River in southern Moravia is connected to the main distribution in Austria (Vlasin 1984a; 1984b).

Sardinia (Italy). There are a few records of this species from western Sardinia (Capocaccia 1965; Lanza 1986), although its current status here is unknown.

Turkey. The Aesculapian snake occurs in three areas of Turkey (Baran and Atatür 1998). In the northeast of the country, this species is found along the Black Sea coast in the provinces of Giresun, Ordu, Rize and Trabzon. This population is continuous with those of Georgia and southern Russia but is separate from the main European distribution. Another population, on the northern slopes of Mount Ararat in eastern Turkey, appears to be isolated midway between the Black Sea population and that from around Lake Urmia in northwest Iran (Schweiger 1994). This species is also found in northwest Turkey, in Adapazari, Bolu, Istanbul, Izmit and Zonguldak provinces, where it is connected to the main European distribution via the Bulgarian and Greek populations.

Georgia. The Aesculapian snake is widely distributed in the western half of Georgia along the Black Sea coast and in the foothills of the Caucasus. One apparently isolated population also occurs in the northeast corner of the country, near Lagodekhi. This species has not been found in areas of Georgia which receive an average rainfall of less than 800mm (Tarkhnishvili *et al* 2002)

Russia. The Georgian Aesculapian snake population continues into southern Russia along the

eastern shores of the Black Sea and at the western end of the Caucasus Mountains. An isolated population appears to occur further inland, south of Rostov, in the "super-province" of Stavropol-Precaspy (Bobrov 2000) although little is known about its status or if it is connected to the Black Sea distribution.

2.5. Threats

2.5.1. Habitat Destruction. This is a particularly serious threat to *Zamenis longissimus* where native forests are felled and replaced with intensive agriculture, conifer plantations or urban development, and many populations have been directly destroyed in this way. Shifting agricultural practices also affect the habitats of this species throughout Europe. In many regions, traditional hedges and dry stone walls occupied by Aesculapian snakes have been destroyed en masse to produce large fields for mechanised arable farming, thus drastically reducing the amount of available habitat for this and many other species.

2.5.3. Roads. Roads pose an increasingly significant threat to Aesculapian snake populations. As vehicle ownership and traffic levels rise, so many new roads are being constructed everywhere in Europe, with a higher proportion now being wide, fast motorways. Since male Aesculapian snakes travel long distances to find mates as, more importantly, do gravid females when seeking nesting sites, both sexes are therefore forced to cross roads with increasing frequency. These snakes may even bask along road verges at certain times. Unsurprisingly, many individuals are killed on roads as a result. The cumulative effects of this artificially high adult mortality can be extremely detrimental to populations of such a large snake, which naturally occurs at relatively low densities (Jaeschke 1971).

2.5.2. Habitat Fragmentation and Loss of Genetic Diversity. Apart from the direct destruction they cause, habitat destruction and road building throughout Europe are increasingly fragmenting the surviving patches of Aesculapian snake habitat. In common with other large species, Aesculapian snakes require extensive areas of suitable habitat and, in many cases, these habitat fragments may simply be too small to support viable populations. Large expanses of poor habitat, as well as very wide and busy roads, may act as effective barriers to snake movements thereby preventing natural dispersal and interchange between populations and leading to a loss of genetic diversity. A genetic comparison of the isolated populations of this species in the Czech Republic (Bohemia) and Germany (Hirschhorn) with snakes from the Balkans appeared to indicate that genetic drift is occurring (Strödicke and Gerisch 1999).

2.5.3. Habitat Management. The majority of Aesculapian snake populations probably do not occur in protected areas. This species is therefore vulnerable to the vagaries of management in the wider countryside. Although it has proved itself to be highly adaptable to human induced habitat changes in the past, and is still widespread in many areas, the Aesculapian snake has come under threat from a number of factors. This species can thrive where forests are managed for timber, although the replacement of deciduous species with conifers has generally been damaging to populations of this snake. Snakes prefer structurally diverse habitats so the increasing mechanisation of the forestry industry, and the resultant clear felling of single large tracts (rather than a small-scale "chequer-board" type of clearance), has also caused declines in many areas. Furthermore, very old deciduous trees, especially those containing hollows and cavities, are frequently removed for a number of reasons, such as health and safety and disease control. If no suitable alternatives are available, this may cause a severe shortage of egg-laying sites for Aesculapian snakes. Although the modernisation of agriculture often directly destroys snake habitats (Section 2.5.1.), the decline of rural economies elsewhere has resulted in the more subtle degeneration of small fields, vineyards and so on. Initially, this can be beneficial for Aesculapian snakes and populations will expand as the amount of scrub and other cover increases. However, such warm, open plots are soon lost to succession and, although the snakes will persist as forest reclaims the land, their populations will undergo perceived declines as the habitat becomes increasingly homogenous.

2.5.4. Illegal Collection. Douglas (1891) mentions that there was once a considerable trade in this species around Schlangenbad, Germany, with country people collecting and selling these snakes to tourists. Although Aesculapian snakes are still occasionally collected and sold illegally, it is not known if this is having any adverse effects on particular populations or in Europe as a whole. Since it is now a protected species, this activity will always take place outside the law and thus remain unrecorded. However, this species is secretive, often hard to detect and would be difficult to collect in

any substantial numbers. In a study of the problems faced by the Italian snake fauna, for example, Filippi and Luiselli (2000) found that there was no threat to the Aesculapian snake from illegal trade in that country.

2.5.5. Persecution. This species was associated with the classical god of healing (the Greek Asclepius and Roman Aeculapius) and was encouraged around temples dedicated to him (Arnold 2002). A pair of mating Aesculapian snakes is also depicted on the modern symbol of medicine that is used throughout the world. However, many herpetologists consider the more docile four-lined snake, *Elaphe quatuorlineata*, to be a more likely model for this symbol. Both species are also symbolic for Christians in some areas and, together with similar species, are integral to an annual springtime religious procession in Cucullo, central Italy. In addition, not only is *Zamenis longissimus* a completely harmless species but its rodent eating habits mean that it is positively beneficial to humans (Andrei 2002). Nonetheless, this species still suffers the same fate of most European snakes when encountered by people and, whether through fear or ignorance, is usually killed on sight throughout its range. It is not known what effect persecution actually has but it may be a serious threat to populations that are already under pressure from other factors. However, the Aesculapian snake is a secretive species and it is probably for this reason alone, rather than any tolerance by people, that it is able to forage so successfully around human habitation.

2.5.6. Other Threats. Other problems that have affected Aesculapian snakes include pollution, the use of agricultural chemicals, overgrazing (which destroys the vegetation cover needed by this species), predation on juveniles by introduced species such as pheasants and the filling in with concrete ("pointing") of the gaps and holes in dry stone walls that are used by these snakes for shelter and foraging. It is not known what effects, if any, climate change will have on the Aesculapian snake but, assuming suitable habitat corridors are maintained to allow for its dispersal, this species should adapt readily. The decrease in the distribution and abundance of this species that has occurred over the last 5,000 years appears to have been due to a cooling climate so, if the climate of Europe becomes warmer in the future, it is entirely possible that the range of the Aesculapian will shift further north once again.

2.6. Current Protection

2.6.1. Species Protection

International Protection. The Aesculapian snake is listed (as *Elaphe longissima*) in Appendix II of the Council of Europe's 'Convention on the Conservation of European Wildlife and Natural Habitats' (the Bern Convention) as well as in Annex IV of the European Community's 'Directive on the Conservation of Natural and Semi-natural Habitats and of Wild Fauna and Flora, Directive 92/43/EEC' (the Habitats and Species Directive), which translates the Bern Convention into EU law.

National Protection. European Union member states have drafted laws that specifically transpose the EU Habitats and Species Directive into national legislation and all therefore afford the Aesculapian snake, as a species of community concern, with strict protection. Every other Council of Europe range state also gives this species some degree of protection under the auspices of the Bern Convention.

2.6.2. Habitat Protection. While EU member states are not specifically required to declare Special areas of Conservation for Annex IV species, the Aesculapian snake is still found within a large number of such sites that were established for other species or their habitats. Similarly, this species occurs in many Special Protection Areas (designated for birds) and is thus well represented in the Natura 2000 site series. In non-EU states it also often occurs in the equivalent series of protected sites known as the Emerald Network. In addition. all countries have various national and local designations of protected area where this species may be found. Nonetheless, this is an extremely widespread species so the majority of populations probably do not benefit from any formal habitat protection.

2.7. Recent Conservation Actions

Recommendation 106 of the Bern Convention (Council of Europe 2003b) makes suggestions for the conservation of the Aesculapian snake in several countries. Measures undertaken to date have been largely concentrated in those countries supporting isolated populations. This is particularly the case in northern Europe where work has been undertaken in Poland, the Czech Republic and,

especially, in Germany (Heimes and Waitzmann 1997). Field surveys, the provision of egg-laying sites and public awareness campaigns have been undertaken in Hessen by the association Naturschutzhaus. Several areas around Wiesbaden and Schlangenbad have also been proposed as Natura 2000 sites (Council of Europe 2003a). Various conservation actions that have benefited this species elsewhere have been less specific and have generally involved a wider range of habitats and other species. A project in the Republic of Moldova, for example, has included the protection of endangered snakes (such as this species), and the management of their habitats, in preparation for a future national park on the Lower Dniester River. Despite several national initiatives, however, little international funding has been available to date for the conservation of *Zamenis longissimus*. Scientific research on this species has been more extensive and much of this work will help to inform conservation actions in the future. Detailed ecological work, which has included radiotracking, has been carried out on *Zamenis longissimus* in France (Naulleau 1987; 1989a; 1992; 1994; Bonnet and Naulleau 1994; Naulleau and Bonnet 1995). At least three extensive studies have also been made on the German populations including research in west Taunus (Heimes 1988; 1990; 1991; 1994) and south Odenwald (Waitzmann 1989; 1992; 1993). Work on the Hirschhorn population resulted in a detailed book about the Aesculapian snake (Gomille 2002). Numerous accounts have also been written about the captive care and breeding of this species (Schulz 1996), which, together with papers on the best procedures for translocations, should provide a good basis for any potential captive breeding program in the future.

3. ACTION PLAN OBJECTIVES

3.1. Overall Goal

The overall goal of this action plan is to ensure the maintenance, and restoration where necessary, of viable populations of Aesculapian snakes as an integral part of the ecosystems and landscapes that this species occupies in Europe.

3.2. Objectives

In order to achieve this goal, it is necessary to identify and then remove (or mitigate for) any threats to Aesculapian snake populations and their habitats. An immediate priority is to halt and reverse any further deterioration of the isolated Aesculapian snake populations in northern Europe, ensuring that habitats with a favourable microclimate in these areas are not lost to either succession or deliberate land use changes. It is also essential to make certain that all other, presently viable, Aesculapian snake populations, including any that may yet be discovered, are fully protected or are taken into account in land management and development planning procedures. The following objectives are integral to this process:

Objective 1. To plan and carry out field surveys to fill all gaps in current knowledge about the distribution and status of the Aesculapian snake.

Objective 2. To ensure that any significant, unprotected populations of Aesculapian snakes, especially on the edges of the species' range, are safeguarded by appropriate land management or where possible by suitable national designations – and also incorporated into the Natura 2000 or Emerald Network site series where possible

Objective 3. To define and quantify "Favourable Conservation Status" targets for the Aesculapian snake, in all countries within its range, in order to plan monitoring programmes and provide an accurate measure of the success of future actions.

Objective 4. To produce management plans (or assist with the amendment of existing plans if necessary) for currently protected areas that support significant Aesculapian snake populations, taking into account the particular ecological requirements of this species and thereby ensuring that appropriate management regimes are established.

Objective 5. To produce guidelines for the management and enhancement of Aesculapian snake populations in the wider countryside in Europe, including advice to foresters, farmers and householders.

Objective 6. To encourage and support scientific research relevant to Aesculapian snake conservation.

Objective 7. To promote a positive public attitude towards Aesculapian snakes and secure the support of all relevant governments, policy makers, organisations, institutions, landowners and individuals.

Objective 8. To improve international liaison and coordination between all those engaged in surveys, monitoring, habitat management and scientific research (to more effectively achieve Objectives 1-8).

4. ACTIONS REQUIRED

4.1. Improved Liaison and Coordination

Conservation efforts to halt the decline of the Aesculapian snake in Europe have been sporadic to date and much remains to be done to ensure the long-term viability of this species. Although conservation is always more effective when carried out by local workers, within their own country, this is a difficult species to work on and international liaison would therefore be beneficial in order to facilitate the exchange of information and ideas and to provide mutual support.

Action 4.1.1. Ensure that the Governments and relevant conservation bodies of all Aesculapian snake range countries adopt this Action Plan.

Action 4.1.2. Establish a central database for survey records and other information on this species.

Action 4.1.3. Develop a common, agreed protocol to standardize further distribution surveys and population and conservation status monitoring of *Zamenis longissimus* in Europe.

Action 4.1.4. Where these do not already exist, encourage the production and implementation of national Aesculapian snake Recovery Plans (in a standard format) for all countries supporting isolated, range-edge populations of this species – i.e. Germany, Poland, the Czech Republic, Italy (Sardinia), Turkey (Mount Ararat population), Georgia (Lagodekhi population) and Russia (population south of Rostov). Ensure that these Plans are formally adopted by the relevant Governments and are thus binding on all key players, e.g. relevant Ministries and National Park Administrations.

4.2. Distribution Surveys

The Aesculapian snake is still very much under recorded in the main part of its distribution. There are conflicting reports about its occurrence in some areas, and uncertainties about whether certain populations are geographically isolated or not. It is highly likely that the current patchiness of records is due to the patchiness of recording effort. Formal and coordinated herpetological recording schemes should therefore be initiated in countries where these do not already exist.

Action 4.2.1. Collate existing records and monitoring results for the Aesculapian snake throughout Europe.

Action 4.2.2. Develop coordinate and support an expanded network of recorders to carry out surveys for Aesculapian snakes as appropriate throughout the range countries of this species.

Action 4.2.3. Use this network to carry out general field surveys for Aesculapian snakes, concentrating on those areas where records are poor or non-existent. Also, investigate those regions between the isolated, range edge populations and the main European distribution for the possible presence of this species, paying particular attention to river valleys and other humid areas.

Action 4.2.4. Carry out additional, more detailed field surveys, where these are still required, to determine the status and conservation needs of isolated Aesculapian snake populations in Germany, Poland, the Czech Republic, Sardinia, (Italy), northeast Georgia, southern Russia and on Mount Ararat, Turkey.

4.3. Habitat Protection

The perceived decline of the Aesculapian snake in Europe indicates that all occupied habitat should be as fully protected as possible, preferably within the Natura 2000 and Emerald Network series. This process is already well advanced in some countries but, in others, more surveys will be required to determine what proportion of Aesculapian snake habitat is already protected and what else needs to be done.

Action 4.3.1. Ensure that key areas known to support substantial Aesculapian snake populations are protected from any threats of further habitat loss by appropriate national designations and where possible, incorporated into the Natura 2000 and Emerald Network series.

Action 4.3.2. Specifically, ensure that the habitats of all isolated range-edge populations of Aesculapian snake in Germany, Poland, the Czech Republic, Sardinia, Turkey, northeast Georgia and south Russia receive full Government protection.

Action 4.3.3. If any major new Aesculapian snake populations are discovered through future distribution surveys, ensure that these are brought to the attention of the relevant governments and conservation bodies and that they receive appropriate protection at the earliest opportunity.

4.4. Habitat Management

The overall range occupied by the Aesculapian snake in Europe appears to have contracted over the last 5,000 years as a result of natural climate change, a process that is obviously beyond control. More recent losses, however, are undoubtedly attributable to human activities, particularly habitat destruction, the development of roads and changes in land management. These are more readily addressed and a series of simple measures, implemented at key Aesculapian snake locations, will ensure that suitable habitats are enhanced for this species. This is particularly important for the isolated populations to the north of the main range (Germany, Poland and the Czech Republic) as these depend on a favourable local climate and are more vulnerable to land use changes.

Action 4.4.1. Prepare general management guidelines for key Aesculapian snake habitats, incorporating these into existing site management plans where applicable.

Action 4.4.2. Implement appropriate rotational coppicing regimes to natural woodland areas supporting important Aesculapian snake populations. These should aim to provide a patchwork of open sunny areas interspersed with woodland of varied height and age structure. In commercial conifer plantations, maintain habitat corridors for Aesculapian snake movements, particularly, along south facing edges.

Action 4.4.4. For isolated Aesculapian snake populations, ensure that connectivity between all areas of habitat is maintained to avoid any fragmentation and that sufficient habitat is available in surrounding areas to allow for population expansion and dispersal. Consider underpasses or "green bridges" where roads form major barriers to the movement of these snakes (and other wildlife).

Action 4.4.5. Preserve old deciduous trees and also provide artificial egg-laying sites (manure heaps or piles of wood chippings) to enhance the breeding success of this species in isolated populations. These should be sited with care, ensuring that female snakes do not need to cross roads to reach them.

4.5. Species Protection

The Aesculapian snake is already legally protected in many European countries, although this has often failed to reduce illegal activities such as deliberate killing. Even with legal provisions in place, these must be enforced to provide effective species protection. Improving public awareness is also of paramount importance in preventing persecution.

Action 4.5.1. Carry out a review of the effectiveness of current legal protection for the Aesculapian snake and its enforcement throughout the range of this species. Provide recommendations for improving the situation where necessary, for example through the imposition of higher penalties for infringements.

Action 4.5.3. Prohibit the issue of any permits for the commercial collection or trading of this species.

4.6. Species Management

Suitable habitat protection and management will be sufficient for most Aesculapian snake populations to recover naturally, thus negating the need for species management. However, some small isolated populations may ultimately require direct intervention to survive. The only feasible option to increase genetic diversity and save such populations from inevitable extinction would then be to implement a translocation programme (possibly involving captive breeding), with viable animals

being released into areas of suitably restored and managed habitat. The re-introduction of Aesculapian snakes to areas where they have already become extinct may also be possible in some cases. These options are expensive and prone to many potential problems, such as the spread of pathogens, so should be carefully planned. It is unlikely that translocations or captive breeding programmes will be necessary for this species in the foreseeable future.

Action 4.6.1. Investigate the requirement for re-introduction and population re-enforcement programmes for *Zamenis longissimus* in Europe, assessing potential methods and costs.

4.7. Population and Conservation Status Monitoring

It is important to regularly monitor Aesculapian snake populations to detect changes in status and to assess the effectiveness of any conservation actions taken. The results can also be used to refine and adjust conservation and habitat management techniques and to prioritise the allocation of available resources. Defining and quantifying "Favourable Conservation Status" for the Aesculapian snake in the various range countries of Europe should be central to this process and will enable a clear set of goals, targets and funding requirements for conservation actions to be produced.

Action 4.7.1. Determine more accurately the current range of known Aesculapian snake populations, especially any possible connections between isolated populations and the main distribution, to assist with the development of specific targets for habitat restoration and re-creation strategies, as well as species re-introduction programmes.

Action 4.7.2. For isolated populations, develop standardised GIS-based methods for the mapping and measuring of prime habitats specifically used by Aesculapian snakes (as well as any potential habitats and dispersal corridors in adjacent areas) to enable the future assessment of changes in the extent and quality of these habitats at all sites.

Action 4.7.3. Produce a standardised methodology for monitoring and calculating the condition of individual Aesculapian snake populations and any future changes to their status.

Action 4.7.4. Using the above methods, establish an internationally coordinated monitoring programme for the Aesculapian snake to regularly determine the conservation status of this species. In particular, routinely monitor the status and habitat condition of the isolated populations in Germany, Poland, the Czech Republic, Italy (Sardinia), Turkey (Mount Ararat), Georgia (Lagodekhi) and Russia (south of Rostov). Inform national governments, the Standing Committee of the Bern Convention and other relevant parties of the results and use these to refine and adjust conservation measures.

4.8. Scientific Research

Appropriate scientific research can be used to inform and refine conservation management. Limited research has been conducted on various aspects of Aesculapian snake ecology so there is still a lot to learn about this species. Radiotracking is one of the most useful techniques for elucidating habitat use by snakes and offers unparalleled opportunities to study Aesculapian snakes in more detail. As much support as possible should be given to academic institutions planning to conduct Aesculapian snake research of this nature, or in any other areas that will be relevant to the objectives of this Action Plan.

Action 4.8.1. Encourage and support scientific research investigating the general ecology, behaviour and habitat use of the Aesculapian snake in the various range countries.

Action 4.8.2. With experienced scientists, develop a series of applied research goals that are relevant to the conservation of Aesculapian snakes, especially empirical work investigating the response of the snakes to various forms of management, such as coppicing and the provision of egg-laying sites.

Action 4.8.3. Encourage and support DNA research and related work on the Aesculapian snake to clarify the taxonomic position of the various populations. Such studies are particularly needed on the populations along the eastern shore of the Black Sea and should include comparisons with *Zamenis longissimus* from Lake Urmia, Iran and *Elaphe persica* from northern Iran and southeast Azerbaijan.

Action 4.8.4. Investigate the potential for research projects looking into the effects of climate change on *Zamenis longissimus*, in particular the isolated populations north of the main European distribution.

4.9. Public Awareness

The Aesculapian snake is not only harmless to humans but is a highly beneficial and effective predator on rodent pests. Despite this, these snakes are still frequently killed throughout their range in the belief that they are venomous. With its association with the medical profession, it should be possible to devise a positive public awareness campaign for this species, above all other snakes, that would generate tolerance and support for its conservation.

Action 4.9.1. Produce appropriate educational and public awareness materials, aimed at local people in all range countries, that stress the conservation importance, docile nature and value of this snake.

Action 4.9.2. At the isolated northern localities, encourage local communities and landowners to provide compost and manure heaps, e.g. in gardens and on farms, as egg laying sites for this species.

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