Habitat use of the Aesculapian Snake, *Zamenis longissimus*, at the northern extreme of its range in northwest Bohemia

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ABSTRACT - Habitat use of the Aesculapian snake (*Zamenis longissimus*) at the northern extreme of its range in northwest Bohemia was studied in two areas with different proportions of man-made structures and urban features. Six snakes were equipped with internal transmitters (giving 171 radio locations in total). Compositional analysis at the home-range scale and location-scale revealed that the snakes used habitats and ecotones non-randomly. Man-made structures were preferred significantly over all other habitat types in both study areas with buildings and their surroundings, stone walls and compost heaps preferred microhabitats in both areas. These sites were used mainly as sheltering places or for thermoregulatory activities. In both areas snakes showed a preference for ecotones, transitional areas between biomes. Urban structures were favoured for nesting and overwintering sites. The prevalence of snakes in man-made edge habitats suggests that in climatically challenging conditions, these otherwise heat seeking snakes prefer different habitats than in more southernly areas of this species' range.

INTRODUCTION

Food availability (Madsen & Shine, 1996), availability of suitable overwintering sites (Reinert & Kodrich, 1982; Reinert, 1993), refuges enabling predator avoidance (Webb & Whiting, 2005) and habitat thermal heterogeneity play an important role in habitat selection by temperate snakes. In northern climates selection of suitable habitats and the timing of activities in snakes largely reflects thermoregulatory requirements (Reinert, 1993). An isolated population of the Aesculapian snake (*Zamenis longissimus*) is found in northwest Bohemia (Central Europe), which is at the northern extreme of the species' range (Gomille, 2002). *Z. longissimus* is a diurnal species that has been extensively studied as regards to feeding ecology (Luiselli & Rugiero, 1993; Capizzi & Luiselli, 1996; Capula & Luiselli, 2002), reproduction (Naulleau, 1992; Naulleau & Bonnet, 1995; Capizzi et al., 1996), habitat preferences (Capizzi & Luiselli, 1997; Filippi & Luiselli, 2001) and spatial activity (Naulleau, 1987, 1989, 1993). However, these studies concerned populations in France and Italy (Lelievre et al., 2010), where warmer climatic conditions prevail. No studies have been undertaken in climatically challenging conditions where winters are longer and summers are cooler. In northwest Bohemia part of the *Z. longissimus* population is associated with man-made structures and many individuals permanently inhabit the embankments of a busy road that passes lengthwise through the area (Kovar et al, 2014; Kovar et al., 2016).

In this paper we decribe activity and habitat preferences of *Z. longissimus* living in this northern enclave in two areas with contrasting habitats: an area with a high proportion of man-made structures (occupied house, farm building, stone walls, garden rubbish, compost heaps, apiary, etc.), including a busy road, and an area with a high proportion of semi-natural habitats (grassland, forested areas, full grown shrub, brooks, rocks, etc.). The specific objectives of the study were: (1) to examine habitat use and refuge selection patterns, with emphasis on man-made structures; and (2) to determine if the presence of the road affected the activity of the Z. longissimus.

MATERIALS AND METHODS

Study site and radio-tracking practices

The study area (329-413 m above sea level) is located in northwest Bohemia, near the village of Straz above Ohre. This is an area where the River Ohre (long-term average flow of 29 m3 . s-1, width 35-45 m) creates a deep valley that separates the Krusne Hory mountains in the north and Doupov Range to the south. At the bottom of the valley, in close contact with the River Ohre, runs the E442 (I/13), a busy two-lane road (width of the roadway 8 m; 4,640 cars, 598 light trucks and 1,466 heavy trucks per 24 hours).

The area is sparsely populated with two small villages consisting of both houses and farm buildings and is topographically complex and comprises a varied mosaic of habitats dominated by woodland and extensively grazed and/or hay meadows with numerous trees, gardens around the houses and outbuildings. The area contains numerous stone walls. The snakes we observed had free contact with five macro-habitats in area A, and six macro-habitats in area B (see Table 1). This was reflected in a very wide range of edge habitats (see Table 4).

The study area is located in a warmer river valley surrounded by colder and more humid mountainous areas to the north and south. Climate conditions are characterised by 140 to 160 days per year with an average temperature above 10 ˚C; long-term average temperature in April = 6-7 ˚C, in July = 16-17 ˚C, in October = 7-8 ˚C; long-term average annual precipitation = 712 mm; solar radiation (monthly averages) in September 2007 and June 2008 was 133 W/m2 and 262 W/m2, respectively.

Field work was carried out in two study areas: area A between 15/06/2007 and 09/10/2007 and area B between 08/06/2008 and 28/09/2008. The shortest distance between the sites was 582 m. Snakes tracked were 2 males and 1 female in area A and 3 males in area B. Study area A (GPS centre 50˚19´57.168´´N, 13˚2´28.835´´E) lies adjacent to the road, and here the snakes being monitored were caught directly in the roadbed to have radio transmitters implanted. On the eastern and western borders are two sets of ten small houses, surrounded by small gardens. Study area B (GPS centre 50˚20´35.428´´N, 13˚3´12.518´´E) is located out of direct contact with the road (over 250 to 300 m), from which it is separated by a wooded hillside. Besides farm buildings to the west and a small farm to the east of here, no man-made structures are present. For the purpose of determining habitat preferences, study areas A (138,200 m2; the greatest distance inside of area 645 m; total length of edge habitats 8,852 m) and B (425,500 m2; the greatest distance inside of area 927 m; total length of edge habitats 20,822 m) are defined as the areas bounded by the minimum convex polygon of the outermost radio-locations of all snakes. Barriers (e.g., river) were taken into consideration. The snakes were located approximately once/twice a week with a telemetry receiver (Sika, Biotrack) and hand-held Yagi antenna. The locations were found by tracking the signal to their proximity and their position was fixed from multiple directions. We have tried as much as possible to avoid visual contact with the snakes. To avoid data autocorrelation radio-locations were approximately evenly spaced in time. This method allowed accurate location and home range estimates (Börger et al., 2006; Seaman et al., 1999). Snake location findings are shown in (Fig. 1). Snakes were followed when they were active. The locations were photographed and habitat and microhabitat type recorded (see Table 1 and 3) without disturbing the snakes. Details about the snakes captured and monitoring times are given in Table 2. These locations were used for compositional analysis.

Table 1. Characteristics of habitats within study areas and distances (mean + SD, median) of radio-locations from the edges of habitats. Abs indicates radio-locations absent in this habitat.

No.	Habitat type	Description	distance (m)
1	grassland	pasture or meadow without shrubs or trees, well insolated sites without shelters	3.0 ± 1.9, 2.5
2	mixture of shrub and full grown trees	sparce trees with non-continuous canopy with abundant shrubs coverage (Rubus spp.) and no herbaceous layer, shaded sites	abs.
3	full grown trees	forest with closed canopy, small groups of tall trees, solitery tall trees, shaded sites	6.7 ± 3.2, 8.0
4	full grown shrubs	dense tall shrubs with closed canopy (hawthorn, sloe, ...), shaded sites	2.5 ± 1.3, 2.5
5	man-made structures	houses with gardens, farm building, stone walls, fancy mosaic of well insolated and shaded sites, two-line asphalt road (width 8 m) with stony ditches, two culverts in western part of area	3.3 ± 2.9, 3.0
6	water	pond and river banks with grass, shrubs and trees	abs.
7	mosaic of shrubs, open sites and short trees	mixture of short shrubs, open sites and scarce short trees, mosaic of insolated and shaded sites	2 (one location)
8	early successional plants	dense mixture of tall plants, grasses and short shrubs, mosaic of insolated and shaded sites	6.7 ± 1.7, 6.5

Data processing

Compositional analysis of habitat is a suitable method to determine habitat selection when there are several animals and when the resources are defined by several categories (e.g. vegetation types; Aebischer et al., 1993). Because *Z. longissimus* are not territorial and hence there is independence of movement in that one individual will not significantly influence the movement of another and all tagged individuals had equal access to all available resource units, habitat use and habitat available were evaluated using compositional analysis. This was carried out at two levels: selection of the home range within the study area (second-order habitat selection), and selection of the relocations within the home range (third-order habitat selection). The sampling units for compositional analysis were the 95 % MCP (minimum concave polygons) home ranges. Compositional analysis was performed in R (R Core development Team, Vienna, Austria) using the Adehabitat package (Calenge, 2007). Because the habitats used are linear or spot structures that *Z. longissimus* often exploit in the landscape, we employed minimum concave polygons (MCP) to estimate home range areas. They are better predictors than minimum convex polygons (MCxP) (White & Garrott, 1990) and kernel estimators (KHR) (Seaman et al., 1999; Laver, 2008), for the data used in this study. All but one home range had an elongated (nearly linear) shape.

Using a line and area measure tools in ArcGIS 10.1 we

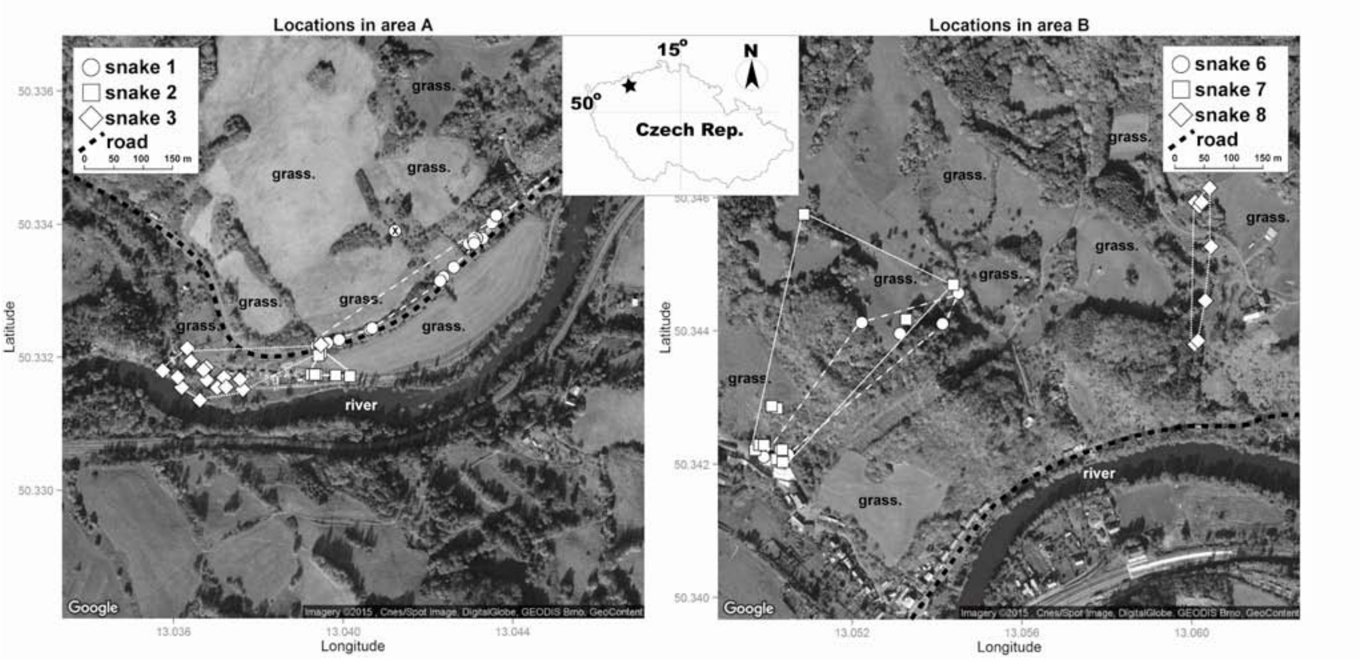

Figure 1. Ariel photograph of the study site showing locations of snakes in area A and B. For clarity minimum convex polygons (MCxP) are plotted for each snake and the road is marked by a dashed line. The location of snake 1 marked with "X" in area A was caused by exceptional movement due to disturbance in home range and the snake returned the same day. Grass areas are marked. Insert shows map of Czech Republic with location of the study locality represented by the star symbol.

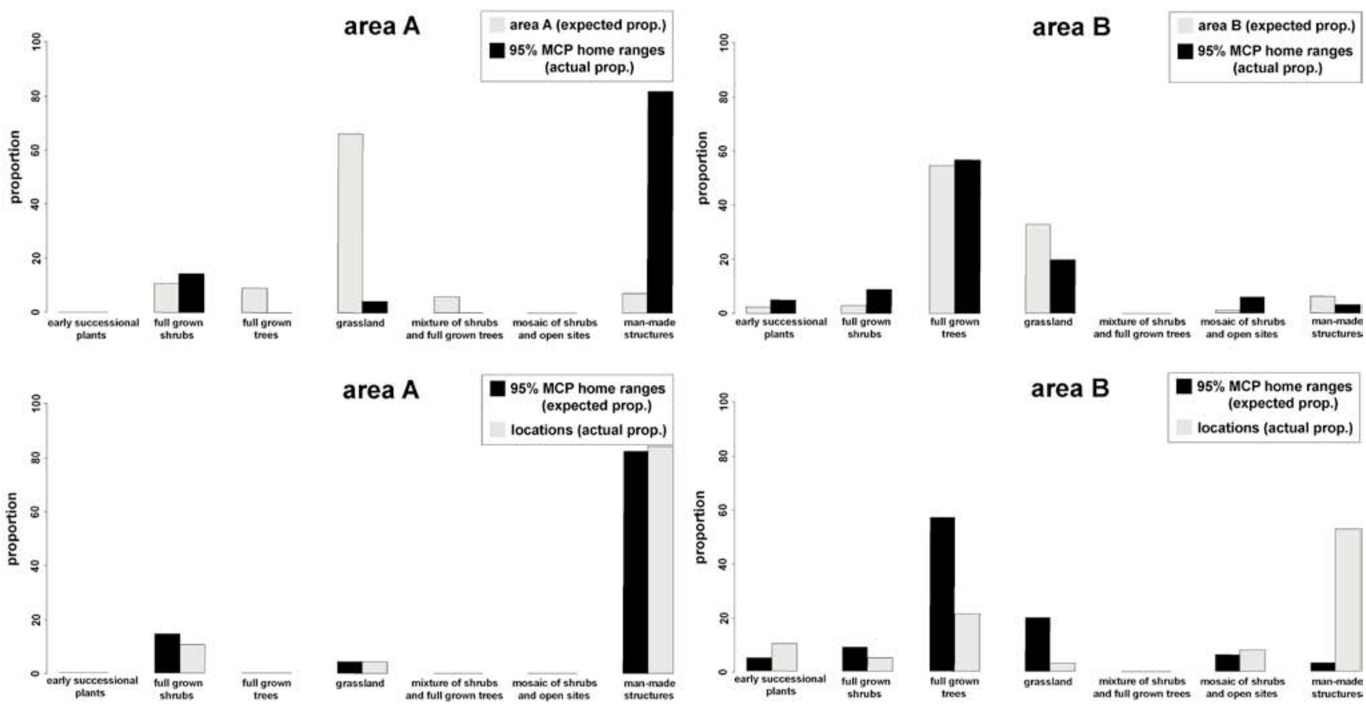

Figure 2. Habitat preferences based on Compositional Analysis (expected vs. actual proportion of habitats). The proportion of habitat types in study area vs. habitat types in 95 % MCP (minimum concave polygon) home ranges (home-range scale) and proportion of habitat types in 95 % MCP vs. habitat types of radio-locations (location scale).

estimated and visualised MCP home ranges and length of all ecotones in our two study areas. These ecotones were classified according to their composition (two types of habitat constituting the ecotone, see Fig. 2). We compared ecotone use to ecotone availablity using compositional analysis (second-order and third-order ecotone selection) (Aebischer, 1993).

Transmitter implantation

The internal transmitters (PIP 2 IMP Biotrack, Biotrack Ltd., United Kingdom, weight 2,1 g) were implanted in the peritoneal cavity under general anesthesia two to three days after capture. The snakes were first weighed and their health status checked. Surgery was performed under sodium pentobarbital anesthesia, and every effort was

Table 2. Data on *Z. longissimus*, times of tracking, distances (m) of radio-locations from the edge of habitat.

Area	A	A	A	B	B	B
Snake No.	1	2	3	6	7	8
Sex	male	male	female	male	male	male
Weight(g)	350	350	400	209	374	150
Tracking period	18/6/07 - 9/10/07	24/6/07 - 25/9/07	15/6/07 - 9/10/07	8/6/08 - 4/9/08	8/6/08 - 31/8/08	8/6/08 - 4/10/08
Number of radio-locations	39	24	27	17	27	37
Distance (m) of radio-locations from edge of habitat (mean; SD; median)	2.5; 2.9; 1.4	1.4; 1.7; 0.7	3.8; 3.5; 4.2	2.0; 0.4; 2.1	4.2; 1.9; 5.1	4.8; 1.9; 5.8

made to minimise suffering. As premedication, we used a combination of 0.25 mg/kg medetomidine (Cepetor inj., 1 mg/ml, CP - Pharma, Germany) + 0.12 mg/kg butorphanol (Butomidor inj., 10 mg/ml, Richter Pharma AG, Austria) + 10 mg/kg ketamine (Narkamon 5 % inj., 50 mg/ml, Spofa, Czech Republic). In 20 minutes, the snakes were sufficiently relaxed, safe to intubate (endotracheal tube, 1.3 x 45 mm, Vasocan Braunüle, B. Braun Meisungen AG, Germany) and subject to inhalation anaesthesia by a mixture of isoflurane (Forane, Isofluranum 100 ml, Abbott Laboratories Ltd., United Kingdom, induction 2 %, maintenance 1 %) and oxygen (0.25 l/min). Following disinfection (Betadine, Iodopovidonum 100 mg/ml, Egis Pharmaceuticals Ltd., Hungary), an incision was made in the transition of dorsal into ventral scales (i.e., laterally at the beginning of the caudal third of the body). A disinfected transmitter was then inserted into the body cavity. The average duration of surgery was 16 minutes. Once the surgical wound was closed, the isoflurane supply was stopped (10 min. after intubation) and the snakes remained on oxygen alone (5 min.). Atipamezole (Revertor inj., 5 mg/ml, CP - Pharma, Germany) was administered intramuscularly as the medetomidine antagonist, followed by extubation, after which the snakes were placed in an incubator (28.5 ˚C). Recovery from the anesthesia averaged 1 hour and 23 minutes. All snakes were returned to the wild 3-4 days following implantation of transmitters at the same location they were caught.

RESULTS

Habitat preferences

Home-range scale: Compositional analysis demonstrated that 95 % MCP home range selection by snakes was non-random within the study areas ($\lambda = 0.10$, $P = 0.018$), and indicated urban structures were preferred significantly over all other habitat types in area A; ranks in order of selection: 1) urban structures 2) grassland 3) full grown shrub. The results also indicated that habitats of "mixture of shrub and full grown trees" and "full grown trees" were avoided. In area B "mosaic of shrubs, open sites and short trees" were selected in greater frequency than others. The rankings were in order of selection: 1) mosaic of shrubs, open sites and short trees 2) early successional plants 3) full grown shrubs 4) urban structures 5) grassland 6) full grown trees.

Location-scale: Compositional analysis of selection at the location-scale indicated that the snakes used habitats within their 95 % MCP home range non-randomly ($\lambda = 0.13$, $P < 0.01$) being located in urban structures more frequently in comparison to other habitat types in area A; rankings were in order of selection 1) urban structures 2) full grown shrub 3) grassland. Habitats with "mixture of shrub and full grown trees" and "full grown trees" were avoided. In area B rankings were in order of selection 1) urban structures 2) grassland 3) full grown trees 4) early successional plants 5) mixture of shrub open stands and short trees 6) full grown shrub (see Fig 1).

Snake behaviour in microhabitats are shown in Table 3. The results were as follows (expressed as a % of the locations), area A: hidden 44 %, basking/thermoregulation 34 %, moving 11 %, unknown 6 %, partly hidden 5 %; area B: hidden 53 %, basking/thermoregulation 47 %.

Linking *Z. longissimus* to edge habitats was essential in both areas. The distance of snake locations from the edges of habitats for individual snakes ranged from 0.0 m to 14.2 m (mean ± SD = 2.6 m + 2.9, median = 1.4 m) in area A and from 0.0 m to 7.4 m (mean ± SD = 4.0 m + 1.9, median = 4.1 m) in area B, respectively (see Table 2). This was significantly different from the average situation in area A (ANOVA, $r^2 < 0.001$, $P < 0.001$) and B (ANOVA, $r^2 < 0.05$, $P < 0.001$) respectively - the distances from edges ranged from 0.0 m to 339.4 m (mean ± SD = 56.7 m + 68.4, median = 26.3 m) in area A and from 0.0 m to 725.8 m (mean ± SD = 112. 4 m + 143.5, median = 42.9 m) in area B, respectively. Snakes penetrated deepest into areas with "full grown trees" (mean ± SD = 6.7 m ± 3.2, median = 8.0) and "early successional plants" (mean ± SD = 6.7 m ± 1.7, median = 6.5) (see Table 1). Of the radio-locations in areas A and B, 97 % and 100 %, respectively fell within a 10 m-wide buffer zone along the interfaces. The majority (84 % and 53 %) of the radio-locations in areas A and B respectively fell within a 5 m-wide buffer zone (see Fig. 1). These results indicate that the vast majority of radio-locations in each area were situated in edge habitats (= ecotones).

In areas A and B, 12 and 16 types of ecotone where snakes were found were identified. Some ecotones occurred only in one or the other area, so in total 19 types of ecotone with snakes were identified (see Fig. 3 and Table 4). On a home-range scale Compositional Analysis demonstrated

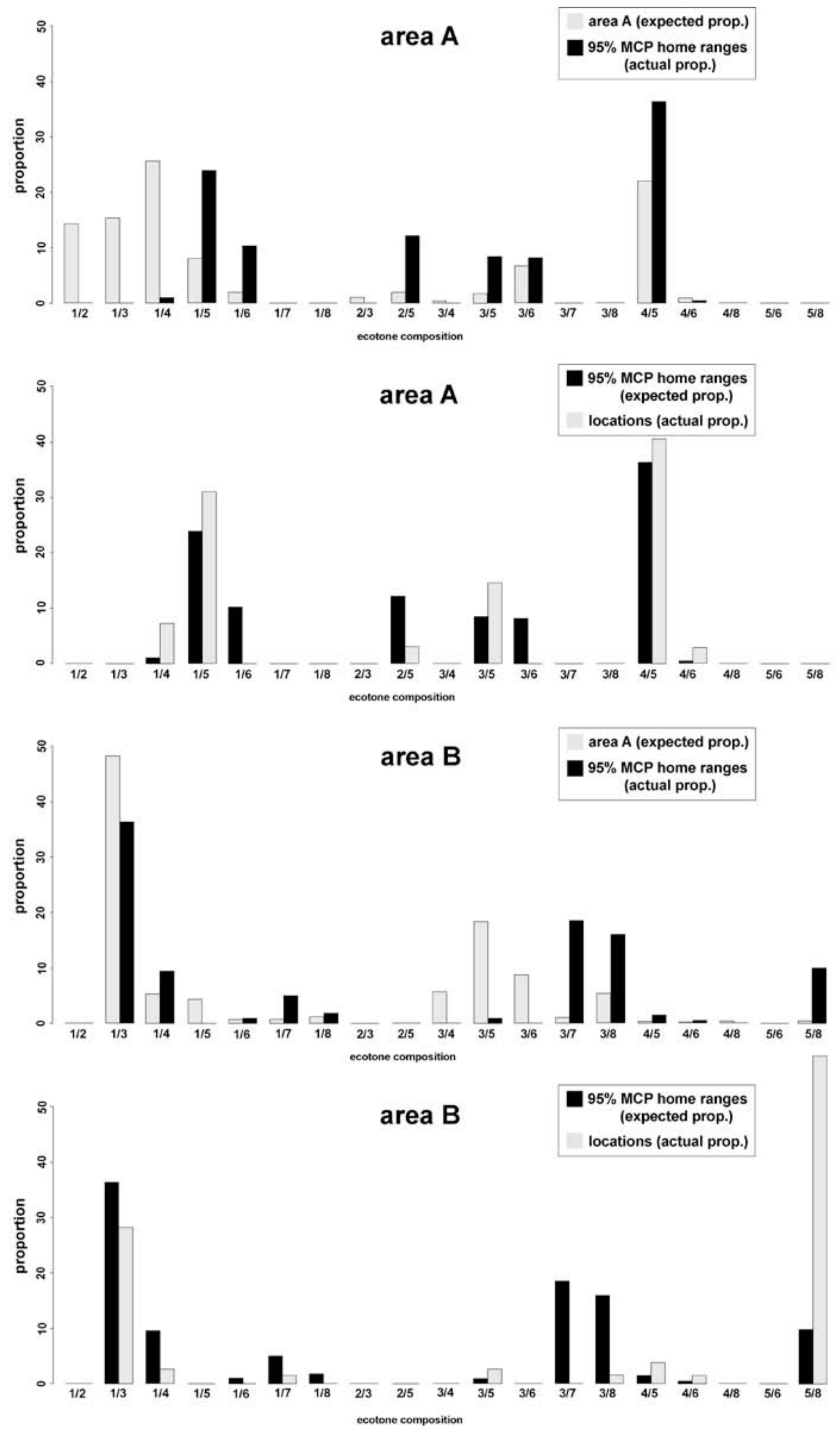

Figure 3. Ecotone preferences based on Compositional analysis (expected vs. actual proportion of ecotones). The proportion of ecotone types length in study area vs. ecotone types length in 95 % MCP (minimum concave polygon) home ranges (home-range scale) and proportion of ecotone types length in 95 % MCP vs. ecotone types of radio-locations (location scale). Figure couples in X axis indicate the two types of habitat constituting the ecotone: 1/2 = grassland / mixture of shrub and full grown trees, 1/3 = grassland / full grown trees, 1/4 = grassland / full grown shrubs, 1/5 = grassland / man-made structures, 1/6 = grassland / water, 1/7 = grassland / mosaic of shrubs, open sites and short trees, 1/8 = grassland / early successional plants, 2/3 = mixture of shrub and full grown trees / full grown trees, 2/5 = mixture of shrub and full grown trees / man-made structures, 3/4 = full grown trees / full grown shrubs, 3/5 = full grown trees / man-made structures, 3/6 = full grown trees / water, 3/7 = full grown trees / mosaic of shrubs, open sites and short trees, 3/8 = full grown trees / early successional plants, 4/5 = full grown shrubs / man-made structures, 4/6 = full grown shrubs / water, 4/8 = full grown shrubs / early successional plants, 5/6 = man-made structures / water, 5/8 = man-made structures / early successional plants.

that ecotone selection by snakes was non-random within the study areas (λ = 0.003, P < 0.001). At location-scale Compositional Analysis at the location-scale revealed that the snakes used ecotones within their 95 % MCP home range non-randomly (λ = 0.016, P < 0.001). Ranks of ecotone preference are shown in Table 4.

DISCUSSION

Habitat preferences (edge habitats)
Both areas in the study localities differed mainly in the proportions of man-made structures (urban features). While they constitute a significant proportion in area A (this area is traversed by the busy road), in area B, they are only minimally represented. Here the major part of the area consists of forest and meadows. Both areas share a high heterogeneity of environments, with a number of transitions between them.

Closed canopy habitat, preferred in the warmer parts of the species range in southern Europe (Lelievre et al., 2011), were avoided in our study localites except when utilising edge habitat. For example, *Z. longissimus* is considered semi-arboreal (Naulleau, 1987, 1989; Luisella & Rugiero, 1993; Schultz, 1996; Lelievre et al., 2010). Pot (1976) found them in trees at a height of between 4 and 7 meters. None of our radio-locations were located on a tree or bush or within any large forested area. Edge habitats exhibit strong edge-oriented thermal gradients, which may allow snakes to adjust body temperature with minimal effort (Wisler et al., 2008). Preference for edge habitats in temperate snakes is a common phenomenon (e.g., Madsen, 1984; Carfagna & Weatherhead, 2006; Row & Blouin-Demers, 2006a; Scali et al., 2008), with high thermal quality of edges, together with prey/shelter abundance, a key factor in selection. This preference is found in both natural and man-made habitats in other species (Blouin-Demers & Weatherhead, 2001). The results also indicate that whilst in optimum climate conditions, *Z. longissimus* operates as a habitat generalist (Lelievre et al., 2011), at the northern limit of the range, probably due to thermal contraints, it selects optimal thermal habitats, such as edges. This is in agreement with data for *Hierophis viridiflavus* (Scali et al., 2008), and *Coluber constrictor* (Plummer & Congdon, 1994). For instance, we considered edge habitat as a 10 meter-wide buffer along habitat interfaces (Row & Blouin-Demers, 2006b; Scali et al., 2008), and 98 % of our radio-locations (irrespective of study A or B) were within this range, with 73 % within a 5 meter-wide buffer. In area A, with a high proportion of urban habitats, this was somewhat higher than in area B. The availability of suitable retreat sites has a major impact on thermal physiology of reptiles (Huey et al., 1989; Huey, 1991) and hence man-made structures may be important in areas with lower temperatures since they offer suitable shelters, basking sites, abundance of prey (e.g., Scali et al., 2008) and potentially low predation pressure by raptors (Meek, 2015).

Our snakes used habitats very unevenly in both study areas with the vast majority of areas inside of their home ranges used only for transits (if at all). Snakes did not move long distances in area A with abundant man-made structures and did not leave these structures. Snake 1 stayed around a group of houses and inside of stone walls near the road ditch throughtout the study with the exception of movement to the north (outside of the area with man-made structures) probably caused by lawn mowing around the home site. The snake returned the same day. Snake 2 stayed most of the time only around a single house and female 3, except during mating stayed in the vicinity of a single garden manure heap, where she eventually deposited here eggs and probably overwintered. Man-made structures were much less frequented in area B and snakes crossed natural habitats here usually with long, fast and probably well-oriented movements. They stopped subsequently in man-made structures for long periods, or returned after travelling longer distances. The trip of snake 7 to the north is an example, where, inside of semi-natural habitats, was located in a pile of rocks and rubbish but subsequently returned to a barn on the southwest of the home range (see Fig. 1). Snake 6 stayed also at the same site for a long period after travelling from a remote probable over-wintering site (dilapidated wall) in the northeast of the home range and subsequently returned to a nearby wall at the approach of winter. Snake 8, located in an area with a wide range of natural habitats was found exclusively in man-made structures. In general, a sedentary lifestyle was also evident from the rankings of behaviour patterns. Moving snakes were observed only rarely with most in concealed locations or were basking. The presence of the same snakes in the same locations, even after several days were frequent. Compositional analysis at location level,

Table 3. Microhabitats selection and activity pattern in area A and B, respectively (expressed as a % of the locations). Abs indicates microhabitat absent in this area.

Microhabitats type	Area A	Area B
freely at surface	42 %	12 %
inside of building	23 %	12 %
inside of stone wall	12 %	14 %
inside of stone heap	abs.	25 %
grassy vegetation	9 %	19 %
inside of garden compost heap	5 %	abs.
inside of heap of rotten plant material	3 %	0 %
below the surface of roadway	2 %	abs.
garden rubbish	< 1 %	16 %
shrub	< 1 %	2 %
under fallen tree	< 1 %	0 %
Activity pattern		
hidden	44 %	53 %
basking/ thermoregulation	34 %	47 %
moving	11 %	0 %
unknown	6 %	0 %
partly hidden	5 %	0 %

Table 4. The length of ecotones (meters and % of total length of ecotones) in area A and B, respectively and ranks of ecotone preferences based on Compositional analysis at home range scale (HRS) and location scale (LS), respectively.

Ecotone		Area A				Area B			
habitat 1	**habitat 2**	**m**	**%**	**HRS**	**LS**	**m**	**%**	**HRS**	**LS**
grassland	mixture of shrub and full grown trees	1184	13.38			0	0.00		
full grown shrubs	man-made structures	1949	22.02	1.	1.	83	0.40	7.	4.
grassland	man-made structures	720	8.13	2.	3.	906	4.35		
grassland	full grown shrubs	2288	25.85	3.	5.	1031	4.95	10.	6.
full grown trees	man-made structures	158	1.78	4.	2.	3815	18.32	11.	2.
mixture of shrub and full grown trees	man-made structures	177	2.00	5.	4.	0	0.00		
man-made structures	early successional plants	0	0.00			36	0.17	1.	1.
full grown trees	mosaic of shrubs, open sites and short trees	0	0.00			176	0.85	2.	
grassland	mosaic of shrubs, open sites and short trees	0	0.00			96	0.46	3.	7.
grassland	full grown trees	1365	15.42			10068	48.35	4.	3.
full grown shrubs	water	104	1.17			38	0.18	5.	5.
full grown trees	early successional plants	0	0.00			1149	5.52	6.	8.
grassland	water	170	1.92			116	0.56	8.	
grassland	early successional plants	0	0.00			239	1.15	9.	
mixture of shrub and full grown trees	full grown trees	84	0.95			0	0.00		
full grown trees	full grown shrubs	58	0.66			1165	5.60		
full grown trees	water	595	6.72			1784	8.57		
full grown shrubs	early successional plants	0	0.0			97	0.47		
man-made structures	water	0	0.0			23	0.11		

thus probably better reflects habitat preferences of snakes in both areas than the compositional analysis at home-range level.

Road

Different species of snakes (Seigel & Pilgrim, 2002; Andrews & Gibbons, 2005; Jochimsen, 2005; Meek, 2015) and lizards (Meek, 2014) react differently to road traffic, and knowledge of their reaction to the existence of a road can help clarify the significance of the impact of road traffic on the local population (Andrews, 2003; Shine et al., 2004). The busy road passing through the center of our area A was not an impassable barrier for the snakes, but became a part of their home range, and the habitats of many snakes were located very near to it. To cross the roads snakes used the culverts that run under it. While mortality of adult snakes attempting to cross roads is very low, the mortality of newly hatched young snakes is significant (Kovar et al., 2014) suggesting the road could represent an ecological trap. The activity of snake No 1 actually ran parallel with the road. Home ranges along a road is not uncommon in snakes (Fitch, 1999; Sealy, 2002; Shine et al., 2004). The retreats under roads constitute the high-quality refuges and especially at night the Aesculapian snakes sheltering under roads are able to maintain high and stable body temperature, irrespective of ambient temperatures (Lelievre et al., 2010).

It is recognised that the present results although statistically significant, are derived from limited numbers of monitored snakes (3 + 3 individuals), radio-locations (171) and time (1 + 1 season). However, due to the uniqueness of the local population, it is important that a data base is now available to facilitate additonal research. This could include between-sex differences of habitat preferences, the seasonal changes in preferences and identification of mating, eggs-laying and wintering habitats.

Conclusions for the conservation of Aesculapian snakes

The importance of man-made structures for the survival of the population of *Z. longissimus* in our study area is evident. Since the 1950s there have been significant changes in land use, resulting in the reduction of landscape mosaics, spreading of forest and the gradual disappearance of scattered man-made structures from open, originally agriculture, landscape. Their artifacts (eg. dilapidated stone walls), still remain, but gradually disappear and become overgrown with vegetation. Since we can not expect a return to traditional agricultural land use, conserving the remaining stone walls and other man-made structures is crucial for the conservation of *Z. longissimus*.

Local people do not harm the snakes, however continuing concentration of snakes around human settlements could become a biological trap if this were to change. Enhancing the ecological conditions of the surrounding habitats is one way to reduce this risk.

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