RESEARCH ARTICLE

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Spring basking by *Vipera aspis*: Observations from Italy and France on the displacement distances of basking vipers from their hibernacula

LORENZO RUGIERO[1], LEONARDO VIGNOLI[2], LUCA LUISELLI[14,5] & ROGER MEEK[3*]

[1]IDECC–Institute for Development, Ecology, Conservation and Cooperation, via G. Tomasi di Lampedusa 33, 00144 Rome, Italy
[2]Department of Science, University Roma Tre, Rome, Italy
[3]7 rue George Clemenceau, Chasnais, 85400, France
[4]Department of Applied and Environmental Biology, Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria
[5]Département de Zoologie, Faculté Des Sciences, Université de Lomé, BP 6057 Lomé, Togo
[*]Corresponding author Email: Rogermeek85@aol.com

ABSTRACT - Patterns of movement are an important component in animal ecology. In temperate zone reptiles this includes movement soon after emergence from hibernation, often a crucial period for courtship and mating. Due to the effects of climate or habitat, intra-specific differences in movement in different areas might be expected. We examined this possibility using long-term data on the displacements of aspic vipers (*Vipera aspis*) from their hibernation dens in Italy and France; the two sites differed in latitude, altitude and vegetation cover. We found no statistically significant differences between Italy and France in displacement distances from the dens. However, in both countries displacements were significantly greater in the afternoon in both males and females. This was thought to be due to differences in cover between the localities. The likely explanation is that the movement of the sun across the sky may leave morning basking positions in the shade and require the snakes to move further from their dens to continue basking.

INTRODUCTION

Knowledge of movement patterns and frequencies of movement are integral to understanding animal ecology (e.g., Turchin, 1957; Larsen, 1987; Hansson & Åkesson, 2014). For snakes and other ectothermic animals, movement will be limited both spatially and temporarily by the structure and thermal qualities of their environment. Consequently, the movement patterns among different populations of a species in different environments could differ. Although the movement of snakes has been studied in detail in some species (e.g., Gregory et al., 1987; Macartney et al., 1988; Webb & Shine, 1997; Blouin-Demers & Weatherhead, 2002; Himes et al., 2006), the data remain scarce even for many abundant snakes and especially for reptiles after emergence from winter dormancy in temperate zones (Zuffi et al., 1999; Reed et al., 2012). This is often the period for reproductive activity and may be energetically costly for both female and male snakes (e.g., Shine, 1980; Luiselli et al., 1996; Olsson et al., 1997; Bonnet et al., 1999). For example, in the aspic viper *Vipera aspis*, males were reported to lose around 350 mg per day due to post hibernation sexual activity (Saint Girons, 1996).

The aspic viper (Fig. 1) is widespread in Europe occupying a series of different habitat types (Arnold, 2002; Speybroeck et al., 2017) and in most of its range undergoes winter hibernation, frequently occupying the same winter dens across several years (Meek, 2016; Luiselli et al., 2018). A small species (maximum total length at around 85 cm; Corti et al., 2010) it is a capital breeder (Lorioux et al., 2013) that reaches maturity after around 3 to 4 years (Bonnet et al., 1999). Currently much of what is known of temperate viper movements in Europe involves reactions to thermal constraints, including outside of the spring mating season. For example distance movements of up to 164 and 361 m were observed during summer in *V. ursinii* in Hungary, and were associated with avoiding high temperatures (Ujvari & Korsos, 1997). In the Swiss Alps *V. berus* males and females moved similar distances after

Figure 1. Male of *V. aspis* from Oriolo Romano (Italy)

Figure 2. Google Earth map of the study area at Oriolo Romano (Italy), showing the location of the four hibernacula (A, B, C, D)

the mating period (Neumeyer, 1987). Seasonal movements have also been observed in non-viperids, for example, male grass snakes *Natrix natrix* were more active during the spring than summer although females travelled greater distances during July following oviposition (Madsen, 1984).

In this paper we report on the movements of *V. aspis* soon after their emergence from communal hibernacula in two areas of Europe, Italy and France, using data from long-term studies (Rugiero et al., 2012, 2013; Meek, 2013, 2014; Luiselli et al, 2018). This time of year is usually the mating period for *V. aspis* and we were interested in comparing their movements in habitats that differed in latitude, altitude and vegetation cover and establish whether or not these differences impacted on their movement patterns. The data come from observations on four hibernacula in a single area of Italy and in western France from a single den situated in a fragmented landscape (Luiselli et al., 2018).

METHODS

Italy: Observations were made at four hibernation dens (A, B, C, D in Fig. 2) in an area in the Tolfa Mountains north of Rome, Italy (coordinates: 42°19`N, 12°12`E , altitude 387 m; Fig. 2). The four hibernacula were situated in a mixed area of bushy pastures (*Citysus scoparius* and *Rubus ulmifolius* bushes) and oak forest (*Quercus cerris*), thus in a relatively wooded zone although not far from ecotones created by paths and tracks (Fig. 3). Surveying started from February 1987 and continued throughout the active year until November 2017 (30 years of records). Sampling intensity varied substantially across years and seasons: in some years there were 2-3 visits a week 20 February to 05 March but in other years only once a week. Overall, the

Figure 3. Landscape surrounding hibernaculum A at Oriolo Romano (Italy)

number of annual days in the field was similar across years (for more details see Rugiero et al., 2013 and Luiselli et al., 2018) and thus the accumulated long-term observations represent a large data set.

Linear distances of snake locations from the hibernation dens were determined with a tape measure, during the period 10 October-20 March (Rugiero et al., 2013) although only spring time observations are reported here. In most instances, sightings occurred during sunny and warm days. We restricted the daily observations in spring to avoid impacting on the natural behaviour of the snakes since our primary aim was to measure daily movement (Macartney et al., 1988). In order to minimise disturbance we measured distance travelled from dens only once every ninth site visit. Surveying was between 08.30h and 12.00h and again between 15.00h and 18.00h Central

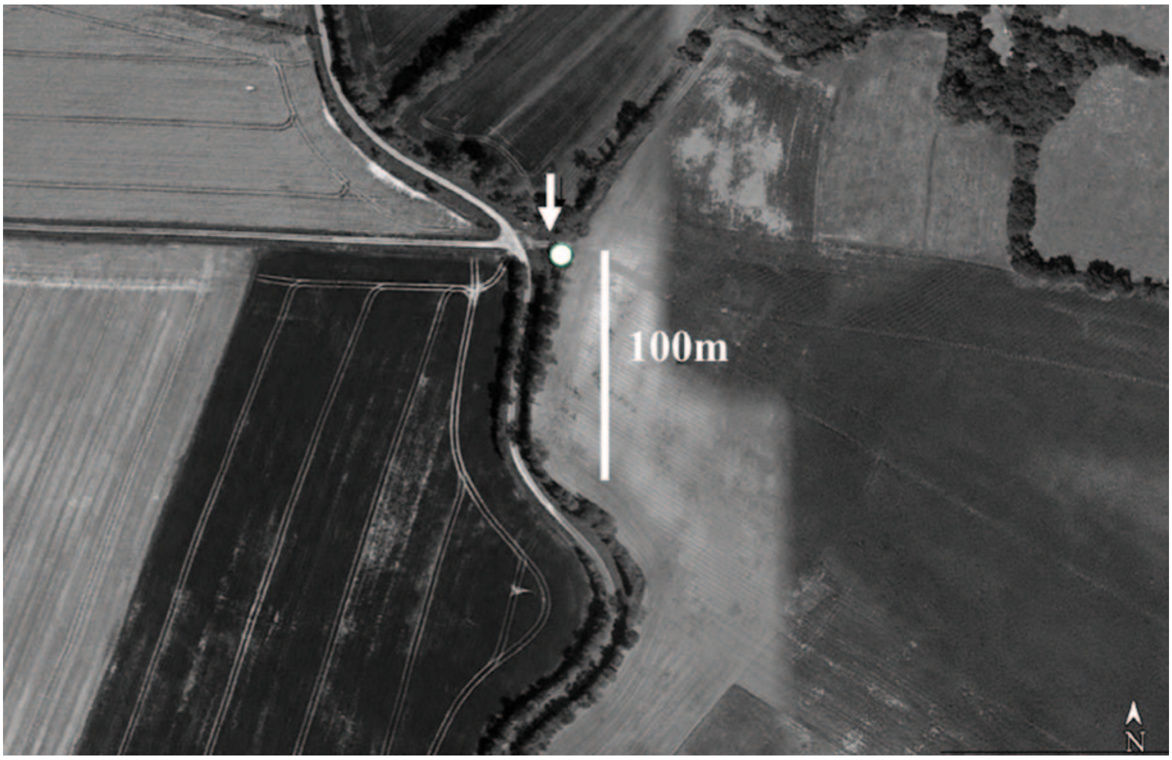

Figure 4. Google Earth map of the study area at Chasnais, western France. Arrow shows location from where the photograph in Fig. 5 was taken and also the direction.

Figure 5. Chasnais hibernaculum with white arrow showing approximate location of the den entrance. The view also illustrates the narrow linear structure of the hedgerow system. Only one viper, a female, was located in the hedgerow to the right in the autumn of 2016 giving birth (Meek, 2016).

European Time (CET) and usually completed within 90 minutes. Detection was made by visual encounter and time of sighting (CET) recorded. Snakes were individually marked by ventral scale-clipping and dorsally painted with a white number allowing the surveyors in the short-term to identify specimens that were already captured without any need for further recaptures.

France: Observations were made at a hibernaculum in Vendée, western France (46˚27`N;1˚53`W; altitude 25 m; Fig. 4). The area surrounding the hibernaculum was mainly composed of agricultural land and patches of woodland, usually connected by hedgerows (Fig. 5). The den area was situated at the northern end of a hedgerow system and formed of a series of discontinuous drainage pipe remnants of approximately 1 m diameter. European ash (*Fraxinus excelsior*) with a dense understory of bramble growth (*Rubus fruticosus*) covered the den area. A combination of autumn leaf fall, drifting soil from agricultural land resulted in debris entering the drainage pipes, leaving openings of around 15 cm at the top of the pipes for entry.

Surveying was carried out between 22 March - 28 May (2013), 12 March - 22 April (2014), 04 April – 28 April (2015), 21 April - 27 April (2016). Most visits were carried out twice daily between 09.20h and 10.50h and 15.30h and 18.40h (CET) and usually completed within one hour. Time of each sighting (CET) was recorded. As in Italy, detection was by visual encounter by walking along both sides of the hedgerow surrounding the den at a distance of 4 – 6 m. This included hedgerows to the north/north-east, west and south (Fig. 4). Farmland stretching from approximately 5-10 m east and west of the hedgerows and the grassy areas next to the road were also searched for snakes. These areas had little vegetation except during the summer months of 2015. Each hedgerow was surveyed once during a visit. All snake locations were recorded and plotted on a map (Google Earth) to determine their approximate distances from the den entrance along with dates of observation.

Statistical Analysis: In Italy there were 505 observations from 59 snakes around their dens (*mean* = 8.6 sightings per individual) and in France 76 observations on 6 snakes (*mean* = 12.7 sightings per individual). To test for differences in displacement from hibernacula before and

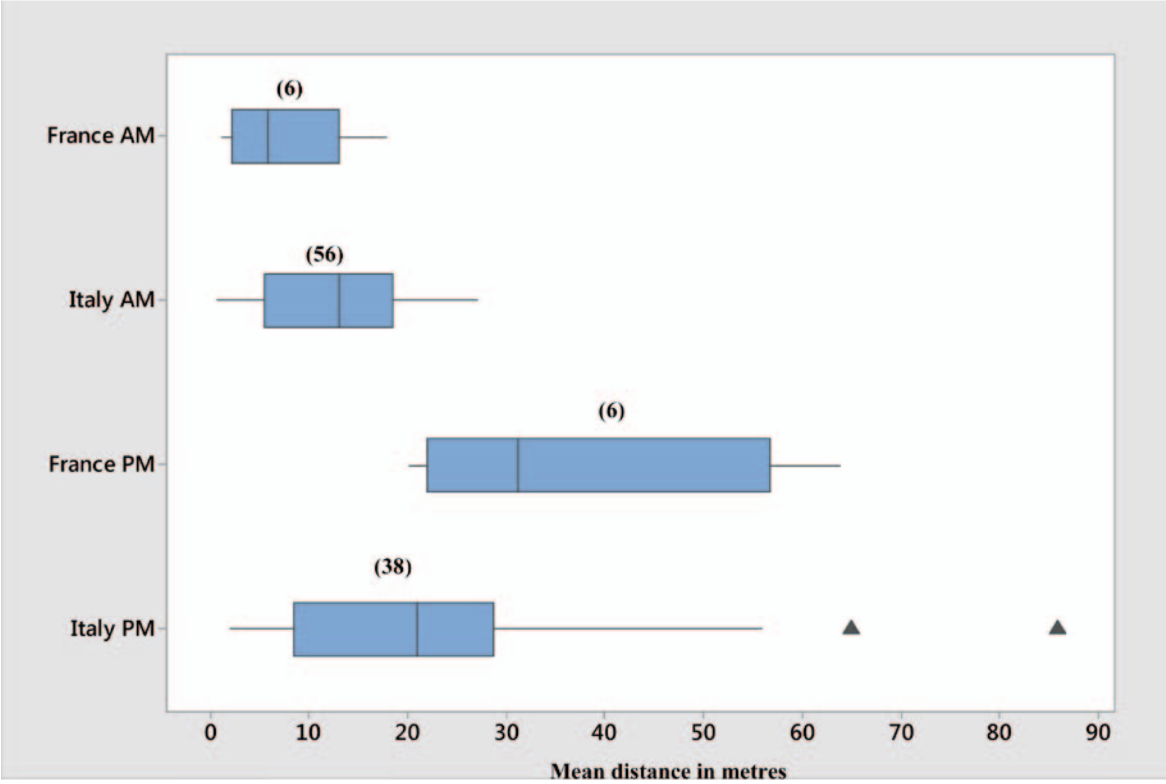

Figure 6. Boxplots of displacement data (in metres) in *V. aspis* from the hibernation dens in Italy and France. Horizontal boxes represent the interquartile ranges, vertical lines within the boxes medians and horizontal lines the ranges. Triangles in the Italy pm data are statistical outliers. Samples sizes are number of *means* of *means* of individual snakes.

after midday and avoiding pseudo-replication, analysis has been applied to the means of the displacements of individual snakes. Statistically, this method employs the properties of the Central Limit Theorem; that is the *mean* of the *means* is equal to the population *mean*. This produced sets of 'morning' *means* and 'afternoon' *means* for comparison. To test that the *mean* values followed a normal distribution the data were subject to Anderson-Darling normality tests. The results gave morning *means* $a^2 = 0.28$, p = 0.51 and afternoon *means* $a^2 = 0.37$, p = 0.29 for France but in Italy for morning *means* $a^2 = 0.96$, p = 0.01 and afternoon *means* $a^2 = 1.19$, p = 0.004. We therefore used a non-parametric Mann-Whitney *U*-test to make comparisons of median displacement distances with α at 5%. Levens tests were used to test for homogeneity of variances in displacement, which is more robust for smaller samples (i.e. viper data in France) and less sensitive to departures from normality (Box & Jenkins, 1976). The test considers the distances of the observations from their sample medians and assumes a null hypothesis of $H_0 : \sigma^2_1 / \sigma^2_2 = 1$. All calculations were performed on Minitab.

RESULTS

Comparisons between Italy and France: Figure 6 shows a box plot of the data from Italy and France. Although Italian snakes were on average found further from den entrances in the morning than those in France, the difference was not significant (Mann Whitney, *W* = 127, p = 0.13) neither was the greater average afternoon displacement by snakes in France (*W* = 185, p = 0.09). There was no significant difference between morning or afternoon variance in displacement between Italy and France either during morning (Leven's test, *L* = 0.86, p = 0.36) or afternoon (*L* = 0.075, p = 0.78).

Table 1. Mean post hibernation displacement distances (m) for male and female *V. aspis* in the morning and afternoon. Note that to avoid pseudo-replication data are shown as *means* of *means* of individual snakes where adequate amounts of observations for individual snakes were made. See text for details.

	Italy				France			
	Males		Females		Males		Females	
	Mean±sd	n	Mean±sd	n	Mean±sd	n	Mean±sd	n
AM	14.7±7.3	21	10.9±7.0	36	5.5±4.6	4	11.3±6.5	2
PM	27.5±23.6	13	21.3±15.0	25	30.8±20.2	4	61.5±6.6	2

Italy: During the morning (before 12.00h) mean linear distance from the den for 57 post hibernation vipers was 12.32m±7.28, with a range 7-27m. The movements were in general greater in the afternoon: *mean* distance = 23.38m±18.29, range 2 – 88m with differences between morning and afternoon significant (Mann-Whitney, *W* = 2272, p = 0.0004). This pattern applied to both sexes and was significant in females (Mann-Whitney *W* = 909.5, p = 0.002 but just outside α at *W* = 316, p = 0.07 for males. Variation in displacement was also greater in the afternoon (*mean* = 25.1±27.0m) in comparison to morning (*mean* = 4.4±4.6m) with the difference significant (Leven's test, *L* = 19.5, p = 0.001). The differences were also significant in both sexes; males $L = 4.7$, $p = 0.03$, females $L = 9.7$, $p = 0.003$.

France: During spring, post hibernation *V. aspis* sightings of a maximum 6 snakes (however numbers declined with time see Luiselli et al., 2018) during the morning surveys (< 12.00h) gave indicated movements from the den area from 1.23–17.8 m (*mean* 7.43m±6.21, n = 6). Snakes moved further in the afternoon with *mean* distances of individuals ranging from 20.1–68.8 m (*mean* = 38.2±19.4, n = 6) with differences between morning and afternoon statistically significant (Mann Whitney, $W = 21$, $p = 0.005$). Variation in movement was greater during the afternoon with the difference significant (Leven's test $L = 12.3$, $p = 0.001$). The employment of means of means for statistical analysis negated comparison between sexes for the French snakes but as can be seen in Table 1 there was greater afternoon displacement in both sexes.

DISCUSSION

Although the study sites in Italy and France differed in latitude and altitude, displacement distances in *V. aspis* were in statistical agreement. In both countries, *V. aspis* generally travelled further from their hibernacula in the afternoon than in the morning. Shorter morning movement is expected in temperate latitudes where it is well known that snake hibernacula are often located in positions where they will catch the early sunshine. Consequently, snakes can begin the day by basking close to their hibernacula. These basking areas will very often be in shade later in the day so that snakes will necessarily have to move further from their hibernacula to remain in the sun. Viitanen (1967) mentions westward movement of *V. berus* in the afternoon and this is comparable to the results reported here, he also quotes Duguy (1958) on movements in *V. aspis* suggesting that *V. aspis* and *V. berus* are similar in this respect.

The tendency for longer displacements in the afternoon in France, compared with Italy, may in part have been due to the immediate habitat in France mostly consisting of a long narrow hedgerow (Figs. 4 & 5). To avoid breaking cover the snakes may have undertaken fewer lateral movements than the Italian vipers, which had more comprehensive cover around them. This is possibly reflected in Table 1 which shows that at the French den females travelled further than males and further in the afternoon (but see above for problems with statistical testing). One of the females regularly travelled to the same basking location approximately 90 m along the hedgerow from the den entrance each afternoon. This is high-risk movement unless it can be achieved under cover (Meek, 2013). However, after mating females must thermoregulate precisely (Lorioux et al., 2013) and to do so are constrained to move to track the sun during the course of the day so that basking is optimised. The benefits for female *V. aspis* of investing in movement to achieve high and stable body temperatures include larger, fitter offspring and fewer stillborn (Lourdais, et al., 2004; Lorioux et al., 2013). However, risk of predation may be increased if snakes repeatedly use the same basking areas as predators may regularly search such localities (Meek, 2013).

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