Reptile habitat preference in heathland: implications for heathland management

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A two-year reptile survey was conducted in a heathland in the north of the Netherlands, using artificial refuges placed in different habitats. The studied habitats differed in their botanical composition and physical structure. Five reptile species were recorded: slow worm (*Anguis fragilis*), viviparous lizard (*Zootoca vivipara*), smooth snake (*Coronella austriaca*), grass snake (*Natrix natrix*) and adder (*Vipera berus*). Randomization tests were applied to assess the relationship between the presence of reptile species and habitat. Highest numbers of reptiles were found in habitats with a combination of common heather and purple moor grass, whereas habitats with common rush scored the lowest. The slow-worm preferred habitats consisting of common heather or crowberry, or a combination of these plants with purple moor grass. The viviparous lizard preferred habitats with common heather and purple moor grass. The impact of current nature management on the maintenance and development of these habitats is discussed, and recommendations are given for reptile faunal management.

Key words: Anguis fragilis, artificial refuges, conservation, habitat, nature management, vegetation structure, *Zootoca vivipara*

INTRODUCTION

In northwestern Europe, heathlands are of high importance for reptiles. In the Netherlands, they provide the optimal habitat for four of the seven indigenous species: sand lizard (*Lacerta agilis*), viviparous lizard (*Zootoca vivipara*), smooth snake (*Coronella austriaca*) and adder (*Vipera berus*). Also the slow-worm (*Anguis fragilis*) and grass snake (*Natrix natrix*) are frequently observed (Stumpel, 2004).

Current nature management methods of heathland are largely landscape oriented, focusing on mosaic patterns in vegetation cover rather than improving the three-dimensional vegetation structure on which reptiles depend (Stumpel, 1992, 2004). Two-dimensional management focusing on plant cover largely ignores habitat structural features required for reptiles (Moulton & Corbett, 1999; Stumpel, 2004). Grazing by livestock is a popular measure for achieving patchiness in the vegetation, and is practiced in almost all heathland areas of the Netherlands; it however does not satisfactorily take the vertical growth of the vegetation into account (Newton et al., 2009). Once site managers are aware of the preferences of reptiles for certain structures in the vegetation, conservation measures can be tailored to the specific needs of species. This paper extends previous studies that for example showed that sand lizards and smooth snake rely on mature heather (Corbett & Tamarind, 1979; Braithwaite et al., 1989), and analyses the habitat use of five species to improve existing management measures.

METHODS

The 280 ha area of this study, Wapserveld, is situated in the province of Drenthe in the north of the Netherlands (52°07'N, 6°17'E). It is a largely open area with a mosaic of wet and dry heaths, pools and sand dunes on partly tilled podzolic soils. The heath is dominated by dwarf shrubs of common heather (*Calluna vulgaris*), cross-leaved heath (*Erica tetralix*) and crowberry (*Empetrum nigrum*), tussocks of purple moor grass (*Molinia caerulea*) and patches of wavy hair-grass (*Deschampsia flexuosa*) and common rush (*Juncus effusus*). Common juniper (*Juniperus communis*) is found locally. Wapserveld is surrounded by mixed woodlands, mainly of pedunculate oak, silver birch, Scots and black pine. Sandy paths give access to the central area, although large parts become flooded when groundwater levels are high. Management comprises grazing by cattle and sheep, removal of turf and the cutting of trees. Localized fires are common in summer.

We used artificial refuges consisting of rectangular corrugated 60 x 50 cm steel plates (2 mm thick, with a trapezium-shaped profile 3.5 cm high; e.g., Riddell, 1996; Mutz & Glandt, 2004). To avoid disturbance by the public, the steel was given a dark green plastic coating, making the refuges well camouflaged and inconspicuous. Seven types of reptile habitat were distinguished, based on the species composition and physical structure of the vegetation (Table 1).

The refuges were laid out in two different ways. Set I was a line transect sample and set II was designed as a stratified sample. Set I consisted of sixty refuges placed 10-20 m apart along a randomly chosen line. This line covered four habitat types and was 947 m in length (Table 2). Set II consisted of thirty-six refuges placed in six habitat types (Table 2). In each habitat type, refuge sites were selected to have a homogeneous vegetation structure surface area of 50 m^2, without risk of flooding. Within each habitat type, three sites were selected randomly,

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Table 1. Reptile habitat types based on characteristic combinations of plants. C: *Calluna vulgaris* (common heather); E: *Empetrum nigrum* (crowberry); J: *Juncus effusus* (common rush); M: *Molinia caerulea* (purple moor grass); g: grazed by cattle.

Code	Characteristic
C	pure *C. vulgaris*; shrubs with mean height 30 cm; cover 100%
E	pure *E. nigrum*; shrubs of 40–100 cm high; cover 100%
EMC	30% *E. nigrum*, 30 % *M. caerulea*, 30% *C. vulgaris*; mean height 30 cm
J	alternation of *J. effusus* tussocks with open patches; hummocks of mosses in *J. effusus* up to 40 cm in height
M	pure *M. caerulea* with tussocks of up to 50 cm; cover 100%
MC	50% *M. caerulea*, 50% *C. vulgaris*; mean height 30 cm
MCg	50% *M. caerulea*, 50% *C. vulgaris*; mean height 15 cm

each containing two refuges 5 m apart. All refuges were inspected weekly. The time of the day varied randomly during the season. Recording took place from June to September 2004 and from March to October in 2005.

The data were analyzed assuming independent observations. Due to the low number of observations, randomization tests (Manly, 1997) were carried out for each species, using a Friedman-χ^2 test statistic. In the randomization test, the test statistic is calculated using the observed data. Subsequently, all animals recorded in 2004 and 2005 were distributed randomly over the habitat types each. In this way a new χ^2 statistic was computed which can be compared with the actual distribution. Non-significance through removing one habitat type is likely caused by significance of the test with all habitat types present. For performing the randomization test, basic data were summed for each habitat type, species and year separately for sets I and II, based on 10^4 simulations. For set I, counts were adjusted to equal path lengths for each habitat type by dividing the observed number of reptiles by the total length of the habitat type (type C 145 m, EMC 94 m, M 132 m, MC 576 m) multiplied by 1000.

RESULTS

All five expected species of reptiles were recorded (*A. fragilis*, *Z. vivipara, C. austriaca, N. natrix* and *V. berus*). Habitat type MC had the highest score in both sets of refuges (Table 3), whereas type J scored the lowest. The four observations of smooth snakes in set II concerned the same individual. Due to its low score in both sets, this snake was excluded from the analysis. For all other species, no individuals were recognized as recaptures. Slow worms (sets I and II) and viviparous lizards (set II) had distributions that significantly differed across habitats. The results for viviparous lizards and adders from set I are marginally significant (P=94.6 and 94.7 of the required 95).

The P values in Table 5 were obtained by repeated removal of one of the habitats. For the slow worm in set II, the significance disappears when habitat type C, E or MC is removed, suggesting a preference of this species for C, E or MC, or all three types. Set I suggests an additional preference of the slow-worm for type EMC. For the viviparous lizard, the significance disappears with the removal of C and M, suggesting a preference for these habitats.

DISCUSSION

Each reptile found was regarded as a new individual, except for the smooth snake. This assumption might not be justified as individuals may be choosy and sedentary for certain periods in the season (Völkl & Thiesmeier, 2002). However, they were recognizable by their size, colour pattern and scars, with no evidence for repeated captures.

We recorded more reptiles in set I compared to set II, which could be caused by longer periods of refuge exposure as well as the number of refuges. Set I was laid out before 2004, and by the time the observations started the refuges were more overgrown; slow worms might only accept refuges deposited for several months (A. Donker, pers. comm.).

Table 2. Number of artificial refuges in each habitat type (see Table 1).

Habitat type	Set I	Set II
C (*Calluna*)	11	6
E (*Empetrum*)	0	6
EMC (*Empetrum*/*Molinia*/*Calluna*)	10	0
J (*Juncus*)	0	6
M (*Molinia*)	4	6
MC (*Molinia*/*Calluna*)	35	6
MCg (*Molinia*/*Calluna* grazed)	0	6
Total	60	36

Table 3. Total number of individuals found in two sets of artificial refuges (I and II). -: refuge absent.

Habitat type	*Anguis fragilis*		*Zootoca vivipara*		*Coronella austriaca*		*Natrix natrix*		*Vipera berus*		Total	
	I	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*	*I*	*II*
C	53	0	24	18	0	0	3	5	5	4	85	27
E	-	32	-	5	-	0	-	0	-	0	-	37
EMC	86	-	12	-	0	-	1	-	7	-	106	-
J	-	2	-	5	-	0	-	0	-	0	-	7
M	12	10	4	1	0	0	3	0	42	1	61	12
MC	36	21	29	9	1	4	59	6	156	17	281	57
MCg	-	1	-	3	-	0	-	1	-	5	-	10
Total	187	66	69	41	1	4	66	12	210	27	533	150

Most reptiles were found in the MC habitat, which is abundant in Wapserveld. Type EMC, which was only present in set I, accounted for 20% of the records. The three plant species from this habitat type form a complex structure, sometimes forming shrubs of up to 1 m in height. Refuges embedded at the foot of such tall structures recorded the highest numbers of reptiles. Less reptiles were found in pure common heather habitat (type C) than in the combination of common heather and purple moor grass (type MC). This was unexpected as type C has been described as an optimal habitat for the reptile species under consideration (Corbett & Tamarind, 1979; Stumpel, 2004). However, the indicator species for such life communities rich in reptiles, the sand lizard *L. agilis*, is absent in Wapserveld. Common heather becomes mature after 40 years and it may reach a height of over 1 m (Watt, 1955; Stumpel, 2004), although it only has a mean height of 30 cm in the present study site, reflecting suboptimal ecological conditions and/or grazing activity. Grazed habitat (MCg) contained fewer reptiles than ungrazed habitat (MC). Earlier observations in the Netherlands showed that adders in particular avoid grazed habitats (Strijbosch, 2002; Stumpel, 2004; van Uchelen, 2006). The negative impact of grazing on reptiles in general has previously been demonstrated (Blanke & Podloucky, 2009; Lenders, 2011). The resulting reduction in structural diversity of the vegetation can be highly detrimental (cf. Offer et al., 2003), depending on the type of livestock and the intensity of grazing.

Slow worms preferred habitat types C, EMC, E and MC, and viviparous lizards preferred the types C and M. In the randomization test for set I, the viviparous lizard and the adder scored very close to 95% (Table 4). For these last two species, further tests were carried out, each time removing one habitat type. For the adder, this led to the disappearance of significance for the types C and EMC, indicating the strong preference of this species for these habitat types.

The relative abundance of slow worms in the heathland of Wapserveld is surprising, as in southern parts of the Netherlands these lizards frequent more shaded habitats (Stumpel, 1985). The viviparous lizard is a characteristic inhabitant of moist and wet heathland (Strijbosch, 1988; Glandt, 2001) and its association with purple moor grass was not unexpected. The majority of adder and grass snake observations in set I were recorded in habitat MC. The adder is relatively abundant in this part of the Netherlands, associated with purple moor grass (Creemers & van Delft, 2009). The grass snake is not a typical inhabitant of heathland, being found more frequently in other habitats in the Netherlands.

When planning conservation measures, it would be important to create or maintain a three-dimensional mosaic pattern of vegetation (representing our habitat types C, E, EMC and MC). Such habitat types develop naturally and are able to persist for decades without management (Stumpel, 2004), and managers should exercise restraint in adopting measures that would slow down or stop their development, such as mowing, grazing, burning and turf removal.

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Table 4. Friedman test. *P*: based on observations; *P*-simulated: based on 10,000 simulations; values in *italic* are significant.

Species	Set I				Set II			
	χ^2	df	*P*	*P*-simulated	χ^2	df	*P*	*P*-simulated
Anguis fragilis	5.4	3	0.855256	*0.9502*	8.2	5	0.855185	*0.9560*
Zootoca vivipara	5.4	3	0.855256	0.9473	8.6	5	0.875814	*0.9822*
Natrix natrix	4.2	3	0.759338	0.7899	3.9	5	0.440255	0.5375
Vipera berus	5.4	3	0.855256	0.9459	4.7	5	0.548266	0.5363

Table 5. Repeated randomization test with deletion of one habitat. Values in *italics* are *not* significant. -C: habitat type C deleted; etc. -: not qualified for this application.

Species	Set I				Set II					
	P -C	P -EMC	P -M	P -MC	P -C	P -E	P -J	P -M	P -MC	P -MCg
Anguis fragilis	*0.8093*	*0.8066*	1	1	*0.9467*	*0.8302*	0.9885	0.9635	*0.8195*	0.9759
Zootoca vivipara	-	-	-	-	*0.9055*	0.9996	0.9913	*0.8845*	0.9609	0.9801

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