MERTENSIELLA **22** | 208-213 | 1. Oktober 2015 | ISBN 978-3-89973-568-0

Compensation of habitat loss for the Common Wall Lizard (*Podarcis muralis*) in the city of Maastricht (The Netherlands)

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Abstract. In the Netherlands, the Common Wall Lizard (*Podarcis muralis*) is a rare and protected species. The city of Maastricht harbours the only natural Dutch population, where it lives on historic city walls and a diversity of urban habitats, such as an abandoned railroad. Measures had to be taken to safeguard the population on the abandoned railway when plans were presented for revitalising the railway. Plans included renewal of the gravel bed and sleepers, restoration of bridges and the removal of vegetation in the years 2007-2008, as well and the usage of the track by freight trains in the future. These activities lead to the destruction and severe disturbance of reptile habitat. To compensate for this, new habitat was created and reptile friendly management of the vegetation is introduced. New habitat was created by building piled walls and wood piles. Twenty-five piled walls were built with a total length of 1100 meter and 37 wood piles were put alongside the track every 50 meter. Common Wall Lizard population size, reproduction success and dispersion were monitored. Reconstruction and translocation proved to have a great impact on the population size in the first year after translocation. However, the population shows both a significant, strong increase since then and annual successful reproduction in the new habitat. The average annual growth of the population over the period 2008-2011 is 60%. Based on the experiences in this project it is advised to develop new habitat five years prior to the destruction of the original habitat. As the railway is not in use yet, the impact of passing trains on the population is unknown.

Key words. Reptilia, Sauria, Lacertidae, *Podarcis muralis*, Netherlands, Maastricht, Native Population, Translocation, Conservation Measurements.

Augleichsmaßnahmen für die Mauereidechse (*Podarcis muralis*) in der Stadt Maastricht (Niederlande)

Zusammenfassung. In den Niederlanden ist die Mauereidechse (*Podarcis muralis*) eine seltene und streng geschützte Art. Die Stadt Maastricht beherbergt das einzige natürliche niederländische Vorkommen, welches historische Stadtmauern sowie unterschiedliche urbane Lebensräume wie verlassene Gleisanlagen besiedelt. Im Zuge einer Revitalisierung einer Bahnstrecke mussten Naturschutzmaßnahmen ergriffen werden, um den Erhaltungszustand der Population nicht zu verschlechtern. Der geplante Eingriff umfasste eine Ausbesserung des Gleisbettes, eine Restaurierung von Brücken und eine Beseitigung von Vegetation in den Jahren 2007-2008, wie auch die zukünftige Nutzung der Strecke durch Güterzüge. All diese Aktivitäten führten zu einer Zerstörung sowie zu starken Beeinträchtigungen des Reptilien-Lebensraums. Zur Eingriffskompensation wurden neue Lebensräume und reptilien-freundliche Pflegemaßnahmen entwickelt. Die Schaffung neuen Lebensraums umfasste die Schichtung von Mauern und Totholzanhäufungen. Insgesamt wurden 25 Schichtmauern auf einer Länge von 1100 Metern und daneben 37 Totholzanhäufungen alle 50 Meter errichtet. Die Maßnahmen wurden von einem Monitoring der Populationsgröße, des Reproduktionserfolges und der Verteilung der Mauereidechsen-Population begleitet. Die Baumaßnahmen und die Umsiedlung hatten einen großen negativen Einfluss auf die Populationsgröße des Vorkommens in den ersten Jahren nach der Umsiedlung. Nichtsdestotrotz zeigt die Population einen großen Zuwachs und eine erfolgreiche jährliche Reproduktion im neuen Lebensraum. Der durchschnittliche jährliche Individuenzuwachs im Zeitraum 2008-2011 beträgt 60 %. Die Erfahrungen in diesem Projekt zeigen, dass neue Lebensräume wenigstens fünf Jahre vor der Zerstörung des angestammten Lebensraums geschaffen werden sollten. Da die Bahnstrecke bisher nicht genutzt wird, ist über den Einfluss des Güterverkehrs keine Aussage möglich.

Schlüsselwörter. Reptilia, Sauria, Lacertidae, *Podarcis muralis*, Niederlande, Maastricht, Autochthones Vorkommen, Umsiedlung, Schutz- und Pflegemaßnahmen.

Introduction

In the Netherlands, the Common Wall Lizard (*Podarcis muralis*) is a rare species that is considered to be critically endangered (Van Delft et al. 2007). The city of Maastricht harbours the only native Dutch populations, the northernmost in its global range. The historic city wall and its direct surroundings are the habitat of the two main populations; which are isolated from each other. Due to habitat destruction and fragmentation, their numbers reached an all time low in the 1980's (Frissenmoors & Tilmans 2009). As a result of a breeding programme and reptile-friendly management of its habitats, the total number grew from less than a hundred in the 1980s to 660 individuals in 2009, based on the maximum number of sightings during seven visits, without taking into account a correction factor for the portion missed during the surveys (Spikmans & Bosman 2010a). Since the beginning of the 1990s, various habitats outside the city wall, including a scrap yard, garden, river embankment and an abandoned railway have been colonised. Then, in 2004, plans were presented for re-

vitalising the railway, which is also inhabited by Common Lizards (*Zootoca vivipara*) and Slow Worms (*Anguis fragilis*). As the Common Wall Lizard is protected by law in the Netherlands, dispensation from the Dutch Fauna and Flora Act had to be obtained. Subsequently, measures were taken to safeguard the population on the railway (Bosman et al. 2011). This article describes the measures taken to compensate habitat loss and the results of the monitoring to estimate their effectiveness.

Method

Impact of revitalising the railway

The railway connects the main station of Maastricht to Lanaken in Belgium, continuing on to Hasselt (B.) It runs along the top of a dike that is flanked by a broad (20 m.) canal to the east, and an industrial area to the west (Spikmans & Bosman 2007). It was in use until the 1980's. After closure, extensive management of the track and surroundings was continued, resulting in a gradual increase of vegetation cover. Suitable habitats arose for the three reptile species mentioned in the gravel bed, and the vegetation along the railway including scrub and woodland edges, bridges and bridgeheads. Three out of the four kilometres in the Netherlands function as a reptile habitat. After colonization in the 1990's, the population of the Common Wall Lizard on the railway grew to a total number of at least 57 individuals in 2005, comprising 10% of the total number of Common Wall Lizards in the Netherlands at that time.

The final plans for revitalizing the railway were presented in 2007 and are for freight transport. They comprised the complete renewal of both gravel bed and railway sleepers, construction of a parallel inspection path, restoration of bridges, bridgeheads, crossings and the removal of vegetation.

Although used railways are known to be suitable habitats for Common Wall Lizards (Schulte 2008), a closer study revealed that in most cases it is not on the railway track itself that reptiles live. Often roadsides, slopes, bridges or abandoned railways situated at several meters distance from the actively used railway track offer very good habitat to Common Wall Lizards. A case describing the reaction of Common Wall Lizards to passing trains (Laufer 1998) told of little reaction from the adults whereas the juveniles fled. However, these observations also appeared to be based on habitat situated several metres away from an actively used track. When the train speed is less than 60 km/h, no negative impact on lizards is to be expected from the air suction created by trains (Mutz & Donth 1996). In the present case, where the lizards are present in the gravel bed of the abandoned railway, reconstruction would lead to destruction and severe disturbance of reptile habitat.

Tab. 1: Available habitat (% of total 2,700 m) for Common Wall Lizard in 2008 and 2009-2011. / Tab. 1: Habitat-Verfügbarkeit (% von insgesamt 2.700 m) für die Mauereidechsen im Jahr 2008 und von 2009-2011.

	2008	2009-2011
Piled wall	19%	40%
Wood pile	5%	5%
Verge	75%	54%
Bridgehead	2%	2%

Plan for compensation of habitat loss

A dispensation from the Dutch Fauna and Flora Act was granted for the revitalization of the railway under strict conditions which include compensation of habitat loss and subsequent reptile friendly management of the vegetation. The timing of the restoration work had to take the biology of the Common Wall Lizard into account. The primary goal was to keep the population level at that of 2005, while also protecting the populations of *Z. vivipara* and *A. fragilis*.

A new habitat for the Common Wall Lizards was created at less than 15 metres away from the new railway by building piled walls and wood piles both on the top and slopes of the railway dike. The piled walls are designed by BfU Wieland Sproten. They vary in height from 0.9 - 2.0 m., width from 0.6 – 1.0 m. and length from 20 to 50 metres. There are three types of walls: (1) 2 m. high walls placed at the foot of the dike (fig. 1a), (2) 1.5 m. high walls on top of the dike alongside the track; these are 1.6 m. wide at the base, (fig. 1b) and (3) smaller walls, (0.9 m. high and 0.9 m. wide) where space was limited. The outside of the walls is of natural stone, *arduin* or Belgian blue stone from a quarry near Sprimont. The core of the walls consists of a mixture of coarse gravel and sand. The walls are broader at the bottom, tapering at an angle of 15° degrees (fig. 1). Table 1 shows the availability of habitat in 2008 and 2009-2011.

The size of newly created wall-structures required as habitat compensation was estimated on monitoring data of 2005 when 57 adults and 38 juveniles were counted. Assuming that at least 25% of the population is not seen during monitoring (Strijbosch et al. 1980), the population was estimated to comprise 119 individuals. The surface area needed per adult individual was based on data in table 2. As a result, 25 walls were built with a total length of 1,075 meter. Also 37 wood piles, made up of three to five branches of Beech (*Fagus sylvatica*), 5 m. long and 20-30 cm. thick were put alongside the track every 50 m. providing habitat for the Slow Worm and Common Lizard as well.

The management of vegetation aimed to develop and maintain a mosaic of patches with low, open, sparse vegetation and tall and dense scrub. Vegetation directly around the walls and wood piles is now cut once or twice a year with removal of the clippings, thus creating suitable habitat for both foraging and egg deposition for Common Wall Lizards. Higher and denser vegetation is

Tab. 2: Amount of wall surface (m^2) used by Common Wall Lizards according to literature. / Tab. 2: Durch Mauereidechsen genutzte Fläche (m^2) nach Literaturangaben.

Location	Habitat type	Used wall surface (m^2) per Common Wall Lizard	Type	Reference
Maastricht (The Netherlands)	Historic city wall	15-25	Home range	Strijbosch et al. 1980
Baden Württemberg (Germany)	Piled wall	10	Wall surface per lizard	Fritz 1987
Enzkreis (Germany	Piled wall	7-40 (average 15)	Wall surface per lizard	Zimmermann 1989
Nordschwarzwald (Germany)	Wall	15-50 (average 20)	Male territory size	Zimmermann 1990
Siebengebirge (Germany)	Quarry	49	Home range	Noppe 1998
Naples (Italy)	Private garden	26	Male territory size	Boag 1972
Siebengebirge (Germany)	Various	3-37	Male territory size	Dexel 1986
Southern Switzerland	Piled wall	15	Male territory size	Weber 1957

maintained by cutting once every two years. Patches of scrub are cut back once every four years.

Eleven of the piled walls and all of the wood piles were in place prior to the start of the revitalization work in winter of 2007-2008, spread out along the railway (Spikmans & Bosman 2007).

The remaining 14 walls were built in early spring 2009. In spring 2008, 109 Common Wall Lizards, 230 Slow Worms and 8 Common Lizards present on the abandoned railway were captured and translocated to the new habitat, dividing the Common Wall Lizards evenly over the newly constructed walls. To prevent recolonization, a steel fence called AmphibianGuard (fig. 2) a German design by Volkmann & Rossbach GmbH & Co. KG was placed between the old railway track and the newly created habitat. It was checked regularly throughout the whole period in which reconstruction activities took place (July 2007 till March 2009). The fence only prevented the return of reptiles to the reconstruction site, but did allow them to disperse from their new habitat to elsewhere. Translocated individuals were marked, using nail polish, to check whether individuals were able to return to their former habitat. All reconstruction activities between July 2007 and March 2009 were closely supervised by an ecologist, who spent a total of 105 days at the site.

Monitoring method and data analysis

The monitoring started in 2008, after the reconstruction of the railway and after part of the compensating habitat had been completed. The population size, reproduction success and dispersion were monitored according to the protocol of the national reptile monitoring programme (Smit & Zuiderwijk 2003). Each year, the site was visited seven times, four times in May - July and three in August - September, noting life stage, sex and location for each lizard sighting. Various habitat types were distinguished: woodpiles and their direct surroundings, piled walls and their direct surroundings, bridgeheads, and other habitat types in the monitoring area (Spikmans 2009a, 2009b, Spikmans & Bosman 2010b, 2011).

The program TRIM (TRends & Indices for Monitoring data) was used for testing temporal population trends based on a log-linear Poisson regression method (Pannekoek & Van Strien 2005). Based on a model describing year effects and site effects, TRIM produces indices for each year as well as giving estimates for trends over the years. Serial correlation between counts in consecutive years as well as overdispersion were incorporated into the model. To analyse the development of the population after revitalization of the railway,

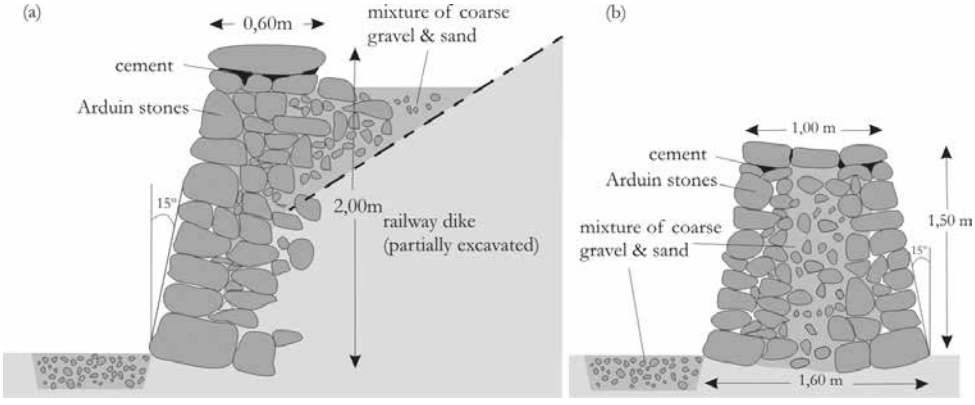

Fig. 1: Sections of a piled wall (a) at the foot of the railway dike, and (b) free-standing. / Abb. 1: Querschnitt durch eine Trockenmauer (a) am Fuß des Eisenbahndammes und (b) freistehend.

Fig. 2: A steel fence was placed between the old railway track and the newly created habitat, to prevent recolonization during the revitalization work. Note the projection of fusion edges. / Abb. 2: Stahlzaun zwischen alter Bahnstrecke und dem neu gestalteten Habitat zur Verhinderung der Rückwanderung während der Rekonstruktionsarbeiten. Photo/Foto: D. Frissen.

trends were calculated using data from piled walls and bridgeheads for the period 2009-2011.

Results

Population development

Figure 3 shows the monitoring data between the years 2000 and 2011. Historical data (2000-2005) are included to show the size of the population during the first years. Since 2000 the maximum number sighted grew from 25 to 95 in 2005. No monitoring data are available form 2006 and 2007. In spring 2008, 100 adults plus 9 subadults were caught and translocated. None of these marked individuals were sighted in their former habitat, indicating that the steel fence prevented a reverse migration of individuals. In 2008, the first year of monitoring after the revitalization a maximum number of 28 Common Wall Lizards were seen in the new habitat, including juveniles. After a slight decline in 2009, the maximum number of Common Wall Lizards showed a significant, strong increase from 25 to 55 in 2011 (TRIM, log-linear Poisson regression model, $p < 0{,}01$). The average yearly increase in adult and sub-adult individuals was 60%. Juveniles were observed in all years during the period 2008 – 2011 but their number did not significantly increase. In 2011 the maximum number of all individuals was still less than half of what it was before the translocation in 2008.

Habitat preference

Figure 4 shows the habitat preference of the Common Wall Lizards in their new habitat. The number of sightings is corrected for the availability of habitat (tab. 1). In this graph preferred habitat has a positive value, zero is neutral and negative is avoidance. In 2008 Common Wall Lizards preferred the wood piles and piled walls, whereas sightings in verges were scarce. Bridgeheads were not available in 2008 because of the construction activities. 2009 shows a decline in the preference for wood piles and bridgeheads were colonized. Since then, bridgeheads are the most preferred habitat, although the availability is low restricted (<2%, tab. 1). Wood piles lose their preference after 2009. Over the years Common Wall Lizards show a steady preference for piled walls.

Occupation of the walls

By the end of the season in 2008, a third of the walls (4 of the 11 walls) had been colonized. Once all twenty-

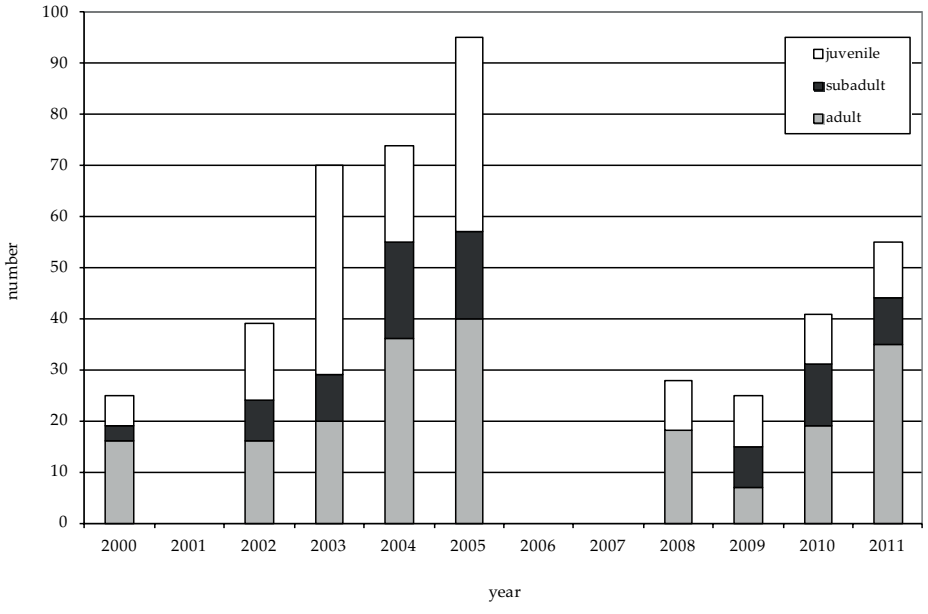

Fig. 3: Yearly maximum number of juvenile and (sub)adult Common Wall Lizards on an abandoned railway for 2000-2007, and for 2008-2011 after its reconstruction. No data are available for 2001, 2006 and 2007. / Abb. 3: Jährliche maximale Anzahl juveniler und (sub)adulter Mauereidechsen auf einer ungenutzten Bahnstrecke für die Jahre 2000-2007 und 2008-2011 nach deren Rekonstruktion. Für die Jahre 2001, 2006, 2007 sind keine Daten verfügbar.

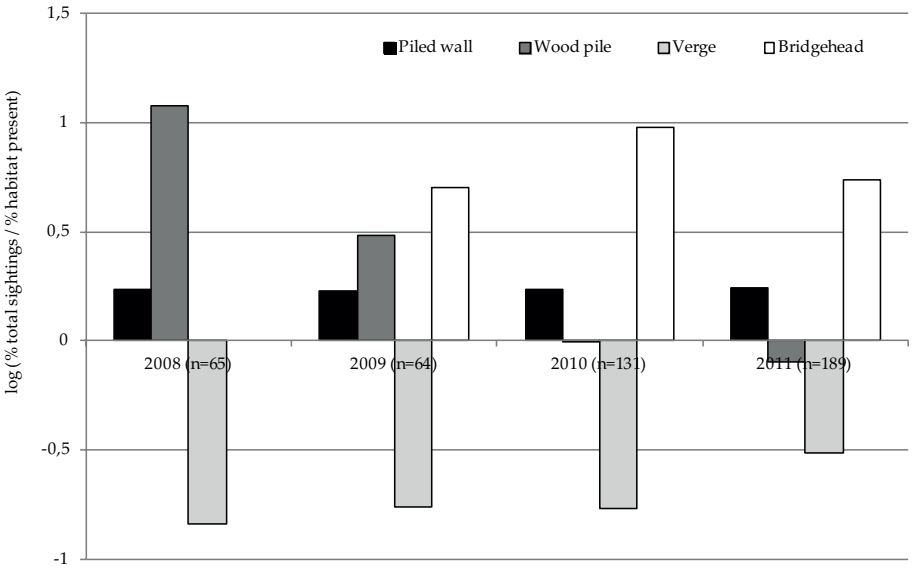

Fig. 4: Yearly habitat preference of Common Wall Lizards between 2008–2011. / Abb. 4: Jährliche Habitatpräferenz der Mauereidechsen zwischen 2008 – 2011.

five walls were available for colonization, this percentage grew to 54 % in 2009 to 81 % in 2011.

Discussion & Conclusions

Up to now, the loss of Common Wall Lizard habitat was successfully compensated by building piled walls and wood piles, and carrying out reptile-friendly vegetation management. Common Wall Lizards show a clear preference for stony substrates, as expected from a heliothermic, saxicolous lacertid species. The negative preference for verges is likely to be caused rather by the short time the species spends here, than by the verges having no function. Verges are expected to play an important role as foraging habitat and are visited for short periods of time, limiting the chance of sighting in this habitat type. Monitoring results show both a strong increase of the population size and successful reproduction each year in the new habitat. With unchanging circumstances (such as climate and predation risk) and considering our calculation on the average annual growth of the population of 60 % the population can be expected to be at its original level (n=119) after five years, that is, in 2013, thereby achieving the primary goal of this project.

However, the translocation of the lizards from their original habitat to the newly created habitat did have a great impact on the population, in the first year after translocation, less than 20% of the lizards were found in their new habitat. Furthermore, chance sightings of increasing numbers of lizards in the vicinity of the railway suggest that some of them had fled from the new habitat. It also suggests that the new habitat was too new for habitation having only been finished in the winter of 2007-2008 and the lizards translocated in the spring of 2008. Such a newly established habitat possibly could not provide sufficient vegetation cover for attracting insects as food supply. Although successful reproduction could be confirmed every year, the number of juveniles remained low, contrary to the number of sub-adults and adults that showed an annual increase. It appears that it takes several years before a newly-created habitat is sufficiently developed to be suitable for Common Wall Lizards. The advice for similar projects is therefore to develop new habitat five years prior to the destruction of the original habitat. The results also show that the translocation of lizards should be avoided, whenever it is possible. It should be mentioned that the presence of an ecologist proved to be indispensable for bridging the gap between the initial plans on the drawing board and the reality of daily practice on the construction site. Hitherto, no trains are using the track as only the Dutch part of the railway has been reconstructed; in Belgium, work is still in progress. Thus, the impact of passing trains is unknown so far, but will be monitored once the railway is in use.

Acknowledgements

We wish to thank the following people and organizations. The studies were carried out on behalf of ProRail (Paul van Betuw and Math Wijermans) and Strukton (Kees van Buul and Henk Slaghuis). Cridi Frissen of CNME Maastricht and Bert Kruijntjens were involved in the development and implementation of the plans and provided valuable input. BfU Wieland Sproten (Theo Wieland, Ulrich Sproten and Ulrich Haese) engineered and supervised the building of the new habitat. Denis Frissen supervised the daily activities during the reconstruction of the railway. Henk Sierdsema helped with the statistical analyses. Claire Hengeveld corrected the English.

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