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Anthropogenic impact or anthropogenic accommodation? Distribution range expansion of the common wall lizard (*Podarcis muralis*) by means of artificial habitats in the north-eastern limits of its distribution range

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Abstract. During 2005-2008, field observations were made on the distribution and habitat occupation by *Podarcis muralis* in the middle Bistrita river basin. Prior to our study, this lizard was known from only 5 localities in Romanian Moldavia (Bicaz, Cheile Bicazului, Lacu Roşu, Gherman and Dodeni). Through the present paper the authors acknowledge the existence of 28 sites populated by *P. muralis* in Moldavia and propose a new model for the range expansion of the species in the area using man-made structures such as road and railway fences and road beds, benefiting from the mild climate provided by the Izvorul Muntelui barrier lake and forming insular populations to further colonize suitable habitats.

Keywords. Carpathian Mountains, Romanian Moldavia, invasive species, Reptiles.

The common wall lizard, *Podarcis muralis* (Laurenti, 1768), is a relatively widespread reptile species, its range comprising of most of Europe: from France and northern Spain to Romania and northern Asia Minor (e.g., Guillaume, 1997; Arnold, 2003). The Carpathian Mountains represent the north-eastern distribution limit of the species (Fuhn and Vancea, 1961; Iftime, 2005). In Romania, the common wall lizard occupies especially the southern and central parts of the Carpathians, southern Dobrugea, the Apuseni Mountains and the Eastern Carpathians (Fuhn and Vancea, 1961; Fuhn, 1969; Ghira et al., 2002; Iftime, 2005; Covaciu-Marcov et al., 2006a, 2006b; Sahlean et al., 2008; Iftime et al., 2008).

Podarcis muralis is a thermophylous species that prefers habitats composed of abrupt cliffs, debris, stone walls (Fuhn and Vancea, 1961; Iftime, 2005), sometimes being found on railway embankments (Covaciu-Marcov et al., 2006 b).

First reference on the presence of the common wall lizard in Moldavia (Eastern Romania) was made by Vancea (1958) at Bicaz, later reconfirmed by Borcea (1976). Fur-

ther records were made by Ionescu et al. (1968), Fuhn (1969), Borcea (1979) and Borcea and Vancea (1981) at Cheile Bicazului. After these findings, no new records were made on the distribution or population status of the common wall lizard in Romanian Moldavia until recent years, when Iftime (2005) reconfirms the existence of the species at Cheile Bicazului. Later, Gherghel et al. (2008) published a mapping of the herpetofauna of the Bistrita river basin and presented 3 new localities for the distribution of the common wall lizard, at Lacu Roşu, Gherman and Dodeni and reconfirmed the presence of the species in the localities already present in the literature (Cheile Bicazului and Bicaz).

The common wall lizard is considered a species of community interest both in Romanian and European legislation, and is listed in the Annex 4 of the Habitats directive of the European Council 92/43/EEC and strictly protected in Romania by Law no. 13/1993, which ratifies the Bern Convention. In addition, the common wall lizard populations from the middle Bistrita river basin are situated at the north-eastern limit of the distribution range of the species, making them a key element for a future conservation plan.

Our study took place between 2005 and 2008, with the purpose of identification of new populations of the common wall lizard at its north-eastern range limit. The study investigated several potential habitats which were identified through direct field observations, digital elevation terrain models and different geological and topographic maps

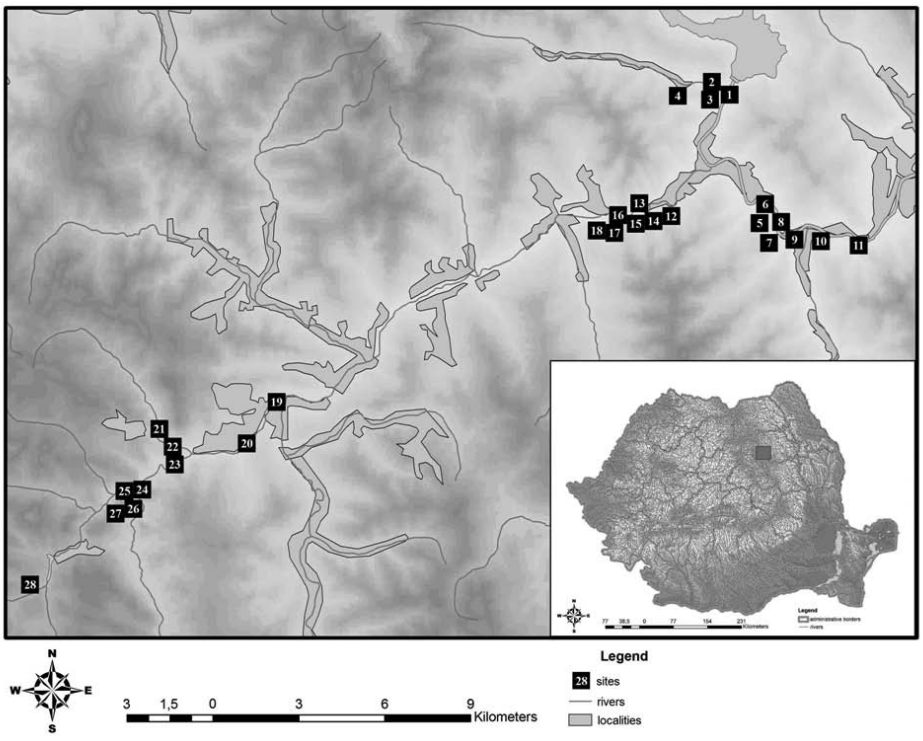

Fig. 1. Map of studied area and geographic position of studied sites.

(1:25000). Namely, we consider as potential habitats all sites with rocky terrain, rock debris or steppe cliffs, crevices and cover vegetation used for shelter against potential threats, but also sites containing man-made structures known to catalyze the spreading of common wall lizards. The GPS coordinates and geographical data were analyzed and verified with DIVA GIS, software also recommended by previous researches (e.g., Rödder et al., 2008; Rödder 2009). Overall, fifty-eight potential sites were identified on an area of 1200 km^2, and were investigated repeatedly (10 times for each site), during different seasons between April and October, raising the chances of finding *P. muralis* populations.

As a result of our investigations, 28 sites (48% of all investigated sites) were detected as being inhabited by the common wall lizard (Fig. 1, Table 1), near the following localities: Izvorul Muntelui, Dodeni, Bicaz, Capşsa, Tarcău, Straja, Bicazul Ardelean, Bicaz-Chei, Gherman, Bîrnadu and Lacul Roşu.

These are grouped in two large populations, separated by forests, agricultural fields and meadows, habitats that do not meet the criteria of being favorable for the species (Fuhn and Vancea, 1961). The subpopulation from Cheile Bicazului (the southern subpopulation) is distributed over an area that comprises 10 sites (90% satellite rocks of the Cheile Bicazului geomorphologic formation) which probably represent the initial spread points for the northern subpopulation (further genetic analysis will be needed in order to test this hypothesis) (Table 1). The northern subpopulation (around the city of Bicaz) is distributed over 18 sites, 94% of which are man-made – railway embankments (59%) and road embankments (41%), only 6% being natural rocky terrain.

Taking into account the fact that the northern group occupies a wide variety of habitats which have been presented as potentially favoring the extension of this species' distribution area (e.g., Covaciu-Marcov et al., 2006; Strugariu et al., 2008) but also the fact that a large number of individuals (20 individuals in a discontinuous gradient from West to East) have been found on the railway beds to the East, towards Straja (East of this locality not having been found any potential habitats), we could assume that the Bicaz population is expanding. The expansion seems to be mediated by elements of anthropogenic origin represented by railway and road beds. The distribution area extension process is on-going in all areas where it lives or has been introduced, being a species with high invasiveness potential (e.g., Hedeen and Hedeen, 1999; Behler and King, 2000).

The fact that *Podarcis muralis* is a highly invasive species was demonstrated by the existence and demographic explosion of North American introduced populations (Hedeen and Hedeen, 1999; Behler and King, 2000; Deichsel and Gist, 2001; Deichsel and Schweiger, 2004) or by the possible new colonization of habitats using railways towards the metropolitan area of Bucharest (Strugariu et al., 2008). As with this last case, we consider that common wall lizard populations from the north-eastern distribution range of the species are dynamic, contributing, in the future, to the extension of the species' distribution range, by colonization of new habitats that meet ecological criteria, but are not yet occupied.

This range expansion may be influenced by the local mild microclimate, a tribute to the presence of the Izvorul Muntelui barrier lake. This has led to a better exposure of rocky habitats, resulting in a better thermic treatment, but at the same time the lake acting as a source of equilibrium, contributing, through summer and multi-annual evaporation, to a temperature rise of approximately 2 ^{o}C, compared to the period before the lake, or compared to other areas in the same climate level (Ciagloc, 1968). Another possibil-

Table. 1. Descriptive data about studied sites.

Site	Altitude	Coordinates		Habitat type	Exposure
	m a.s.l.	N	E		
1	500	46° 56' 25"	26° 06' 02"	Rocks	E
2	480	46° 56' 23"	26° 06' 00"	Road fence	E
3	475	46° 56' 17"	26° 05' 54"	Road fence	E
4	464	46° 57' 24"	26° 04' 53"	Road fence	S-E
5	404	46° 53' 59"	26° 07' 07"	Road fence	S-E
6	400	46° 53' 47"	26° 07' 19"	Road fence	S
7	405	46° 54' 20"	26° 06' 25"	Road fence	S
8	392	46° 54' 20"	26° 06' 36"	Road fence	S
9	392	46° 53' 34"	26° 08' 11"	Railway fence	S
10	390	46° 53' 37"	26° 08' 53"	Railway fence	S
11	375	46° 53' 54"	26° 09' 49"	Railway fence	S
12	454	46° 54' 08"	26° 04' 07"	Railway fence	S-E
13	457	46° 54' 05"	26° 03' 60"	Railway fence	S-E
14	457	46° 54' 01"	26° 03' 46"	Railway fence	S-E
15	457	46° 53' 56"	26° 03' 38"	Railway fence	S-E
16	460	46° 53' 56"	26° 03' 27"	Railway fence	S-E
17	473	46° 53' 45"	26° 03' 08"	Railway fence	S-E
18	485	46° 53' 50"	26° 02' 37"	Railway fence	S-E
19	730	46° 50' 40"	25° 54' 23"	Rocks	S
20	620	46° 50' 05"	25° 53' 07"	Road and railway fance	E
21	830	46° 49' 43"	25° 51' 00"	Rocks	S
22	730	46° 49' 32"	25° 51' 00"	Rocks	S
23	670	46° 49' 30"	25° 51' 03"	Rocks	S-E
24	750	46° 49' 00"	25° 49' 54"	Rocks	S-E
25	770	46° 48' 55"	25° 49' 41"	Rocks	S-E
26	820	46° 47' 60"	25° 48' 12"	Rocks	E
27	850	46° 47' 53"	25° 48' 13"	Rocks	E
28	1060	46° 47'19"	25° 47' 11"	Rocks	S-E

ity, as in other areas of Romania, is the involuntary transport of individuals along with calcareous material from rock quarries (Covaciu-Marcov et al., 2006), these also being present in the study area (Cheile Bicazului rock quarry). However, this second hypothesis it has not been confirmed in the field: East of the Straja rock habitats, road and railway embankments are absent and the animals are not present on the railway beds. This suggests that rock material is improbable to have caused an artificial dispersion of the animals

in the area. By contrast, natural dispersion using road and railway fences or beds has been observed prior to this study in other populations from Romanian Moldavia (Iftime et al., 2008). Artificial dissemination is unlikely, as only one road is present in the area that links between a habitat in which the common wall lizard has been confirmed in Transylvania (Ghira et al., 2002) and Moldavia.

We hypothesise that the railway beds represent a vector that mediates the extension of the distribution range of *P. muralis*, as the railways may be used as migration or linkage habitats among rocky areas or man-made structures, forming small, but dynamic populations. This dispersion model, using railway beds, is considered the prior factor for the invasive success of the common wall lizard in North America, the species using anthropogenic structures as a substitute for natural habitats, expanding its distribution range and colonizing new areas (Hedeen and Hedeen, 1999; Deichsel and Gist, 2001).

Range expansion by means of degraded, man-made habitats has been reported for other lizard species (e.g., *Psammodromus algirus*, Bauwens et al., 1986; *Leiocephalus carinatus armouri*, Smith et al., 2004; *Hemidactylus turcicus*, Meshaka et al., 2006), the process being considered as characteristic for invasive species (Cohen and Carlton, 1998; Ward et al., 2005; D'Amore et al., 2008; Ficetola and Padoa-Schioppa, 2008).

The fact that the common wall lizard produces insular populations is a well known fact and has already been reported elsewhere (e.g., Rochelle et al., 1999; Crnobrnja-Isailovic et al., 2005). In existent populations this is due to habitat fragmentation (Crnobrnja-Isailovic et al., 2005), the phenomenon being one of the major causes for genetic degradation of common wall lizard populations in particular (e.g., Rochelle et al., 1999; Crnobrnja-Isailovic et al., 2005) and of other species generally (e.g., *Liolaemus multimaculatus* and *Liolaemus gracilis* – Vega et al., 2000; *Nerodia erythrogaster neglecta* and *Nerodia sipedon* – Roe et al., 2006).

In the study area, *Podarcis muralis* coexists with other reptile species – *Lacerta agilis, Zootoca vivipara* and *Coronella austriaca*, and different amphibian species – *Bombina variegata, Bufo bufo, Lissotriton montandoni, Mesotriton alpestris, Lissotriton vulgaris* (Gherghel et al., 2008) found in the springs, streams and marsh areas inside the sites.

In the "Romanian Red Book of Vertebrates" (Iftime, 2005), the common wall lizard is listed as a 'vulnerable species', the same source considering the population from Cheile Bicazului as 'heavily affected' because of the activities from the rock quarries.

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