

# Demography of a Slovenian population of the Wall Lizard *Podarcis muralis muralis* (LAURENTI, 1768) (Squamata: Sauria: Lacertidae)

Zur Demographie einer Slowenischen Population der Mauereidechse,  
*Podarcis muralis muralis* (LAURENTI, 1768)  
(Squamata: Sauria: Lacertidae)

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## KURZFASSUNG

In der vorliegenden Arbeit werden demographische Untersuchungen an einer Population der Mauereidechse, *Podarcis muralis muralis* (LAURENTI, 1768), von den Ruinen von Žovnek (unteres Savinja-Tal, Mittelslowenien) beschrieben. *P. muralis* kommt dort syntop mit fünf weiteren Reptilienarten vor. Die Populationsgröße von *P. muralis* wurde durch Markierung und Wiederfang nach Chapmans Modifikation der Petersen Schätzung sowie nach dem kumulativen Verfahren und der Jolly-Seber Methode ermittelt. Die Abschätzung ergab für die Populationsgröße Werte zwischen 75 (Jolly-Seber) und 120 (Petersen) Individuen, für die Mortalitätsrate 17 %, für die Populationsdichte bis zu 6 Individuen auf 100 m<sup>2</sup> und für das Geschlechterverhältnis ungefähr 1:1. Die angewandte Markierungstechnik (Amputation von Endphalangen) hatte keinen signifikanten Einfluß auf die Wiederfangrate.

## ABSTRACT

The demography of a population of Wall Lizards, *Podarcis muralis muralis* (LAURENTI, 1768) inhabiting the ruins of the Žovnek castle (Lower Savinja valley, Slovenia) was studied. There the Wall Lizards live syntopic with five other reptile species. The population size of *P. muralis* was calculated using Chapman's modification of the Petersen estimate, the cumulative and Jolly-Seber stochastic methods. Estimated population size was between 75 (Jolly-Seber) and 120 (Petersen) lizards. Estimated mortality rate was 17 %. The population density was up to 6 specimens per 100 m<sup>2</sup>. Sex ratio was approximately 1:1. There was no significant effect of the marking procedure applied (toe-clipping) on the recapture rate.

## KEY WORDS

Squamata, Sauria, Lacertidae, *Podarcis muralis muralis*, demography, population dynamics, Slovenia

## INTRODUCTION

The Wall Lizard *Podarcis muralis* (LAURENTI, 1768), is widespread across the South of Europe (GRUSCHWITZ & BÖHME 1986; GUILLAUME 1997). In the north of its range in Central Europe, this species is usually restricted to dry, warm, sunny, and rocky or stony spots. *Podarcis muralis* has been studied by a great number of herpetologists, especially in Central Europe, while sound investigations on the demography of populations were undertaken by a handful of authors only, e.g. STRIJBOŠCH & al.

(1980), BARBAULT & MOU (1986, 1988), ZIMMERMANN 1989; BENDER & al. (1996); BENDER (1997); SCHMIDT-LOSKE (1997).

Compared with populations in Western Europe, little is known about the demography and ecology of *P. muralis* in Slovenia (TOME 1996; VOGRIN 1997).

The aim of this paper is to provide mark-recapture technique based data on population size, density and sex ratio of a *P. muralis muralis* population in Central Slovenia.

## STUDY AREA AND METHODS

The investigation was carried out in the ruins of Žovnek castle, near Braslovče (community of Zalec), in the Lower Sa-

vinja valley (Central Slovenia). The study area was about 2000 m<sup>2</sup> in size and situated 400 m a.s.l. The habitat is characterized by

the presence of numerous stones and some stone walls. The vegetation is typical for a rural area (e.g. *Astragalus glycyphyllos*, *Galium aparine*, *Chelidonium majus*, *Dentaria bulbifera*, *Garanium robertianum*, *Galega officinalis*). The castle is surrounded by a Blechno - Fagetum forest community. According to MARINČEK (1987), the area belongs to the prealpine phytogeographic region.

Field research was carried out between April and August 1996. The lizards were caught by hand or noosed, measured for snout-vent length and then marked by toe-clipping. Only terminal phalanges were removed. The injuries were disinfected by means of 96% ethanol. Both male and female specimens with snout-vent length > 51 mm were considered adult (i. e. older than two years; for females see also EDS-

MAN 1986) (for distribution of size classes see fig. 1). The sex of adults was determined through the character state of their femoral pores (see e.g. GRUSCHWITZ & BÖHME 1986; ARNOLD & BURTON 1983). In order to estimate population size a mark-recapture design was used that allowed calculation of Petersen estimate (Chapman's modification) and application of the Jolly-Seber stochastic method, and cumulative method (DONNELLY & GUYER 1994; GREENWOOD 1996). Date of the initial capture action was the 19th of April.

Pearson's correlation coefficient was used to test whether recapture rates decreased with marking. For statistical comparisons,  $\chi^2$  test was used (SOKAL & ROHLF 1995). Data were analyzed using the SPSS® version 6.0 statistical software package for Windows®.

RESULTS AND DISCUSSION

The Wall Lizards studied lived syntopic with five other reptile species: *Anguis fragilis* LINNAEUS, 1758, *Lacerta viridis* (LAURENTI, 1768), *Natrix natrix* (LINNAE-

US, 1758), *Coronella austriaca* LAURENTI 1768, and *Elaphe longissima* (LAURENTI, 1768), but only *P. muralis*, *L. viridis* and *E. longissima* were common. *Coronella*

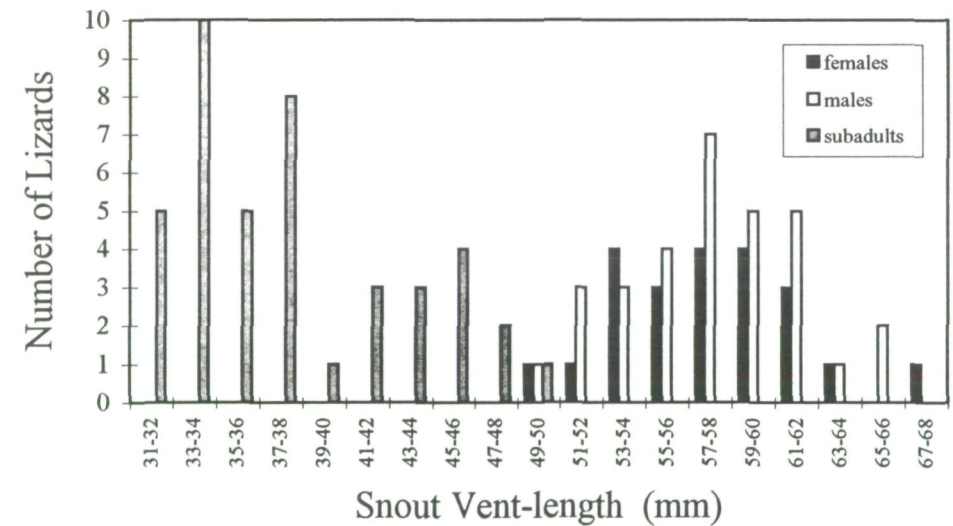


Fig. 1: *Podarcis muralis muralis* sample from the ruins of Žovnek castle (Central Slovenia). Distribution of snout vent-lengths of 92 adult male, adult female, and subadult specimens among size classes.  
Abb. 1: *Podarcis muralis muralis* Stichprobe von der Ruine Žovnek (Mittelslowenien). Verteilung der Kopf-Rumpflängenvon 92 adulten männlichen, adulten weiblichen und subadulten Exemplaren auf Größenklassen.

Table 1: Number of regenerated tails in male (m) and female (f) *Podarcis muralis* at Žovnek castle ruins (Central Slovenia). Nr - Number of lizards with regenerated tail, Nn - Number of lizards with intact tail.

Tab. 1: Die Anzahl der Schwanzregenerate bei männlichen (m) und weiblichen (f) *Podarcis muralis* von den Ruinen von Žovnek (Mittelslowenien). Nr - Anzahl Eidechsen mit Schwanzregenerat; Nn - Anzahl Eidechsen mit intaktem Schwanz.

| Sex | Nr | Nn | $\chi^2, p$    |
|-----|----|----|----------------|
| m   | 6  | 25 | 11.64; < 0.001 |
| f   | 6  | 17 | 5.26; < 0.05   |

*austriaca* was observed to prey on *P. muralis*. A *Natrix natrix* vomited one *P. muralis* specimen after stomach massage. However, based on the frequency of regenerated tails (table 1) as an index of predation pressure (see SHALL & PIANKA 1980; HENDERSON & al. 1981), predation pressure was estimated to be moderate. According to some authors, e.g. BUSACK & JAKSIČ (1982) the frequency of tail loss is not useful a measure of predation pressure on lizards since we must also take into account fighting in both sexes, especially among males for access to females, which could be a reason for tail-loss. Tail-loss due to fighting in both sexes has been reported for *P. sicula* (RAFINESQUE, 1810) and *L. viridis* (see HENLE 1988 and references therein).

During the research work, 92 lizards were caught and marked; 54 out of them were adult. The Petersen method estimated the population size between 63 to 284 individuals (mean value: 120), whereas Jolly-Seber stochastic method indicated 75 lizards (tables 2 and 3). According to the cumulative method, the population consisted of 95 to 100 lizards. Mortality rate calculated from the Jolly - Seber method was 17 %.

Table 2: Population size of *Podarcis muralis* at Žovnek castle ruin (Central Slovenia). Estimations based on Chapman's modification of the Petersen method. N = Population size, SE<sub>N</sub> = Standard error.

Tab. 2: Populationsgröße von *Podarcis muralis* von den Ruinen von Žovnek (Mittelslowenien). Schätzwert aufgrund Chapman's Modifikation der Petersen Schätzung. N = Populationsgröße; SE<sub>N</sub> = Standardfehler.

| Date / Datum  | N   | SE <sub>N</sub> |
|---------------|-----|-----------------|
| 07. May       | 284 | 150             |
| 17. May       | 94  | 39              |
| 24. May       | 78  | 32              |
| 04. June      | 137 | 70              |
| 13. June      | 63  | 25              |
| 09. July      | 63  | 25              |
| Mean / Mittel | 120 | 57              |

Mortality rate calculated includes death and emigration events.

Considering the Petersen estimate based population sizes of *P. muralis* as found on different days, population size decreased during the research period (table 2). There are several possible explanations for this observation. Until 1994, the castle ruins were almost completely covered by bushes and other vegetation. In 1994, local people cut down the bushes and cleaned the ruins. I infer that this intervention had a strong positive influence on the population of *P. muralis*. The population probably started to increase as a result of an improvement of the local microclimatic conditions. It is quite possible that the population size reached a climax at the outset of the research, in 1996. Due to high density and very aggressive intraspecific behaviour observed during the study, some specimens may have emigrated into the neighboring habitats, including a vineyard suited for this species. I observed some subadults in

Table 3: *Podarcis muralis* of the Žovnek castle ruin (Central Slovenia). Estimates of population size (N<sub>i</sub>), population gain (g<sub>i</sub>), and survival rate (φ<sub>i</sub>) and their standard errors; calculated using the Jolly-Seber stochastic method.

Tab. 3: *Podarcis muralis* von den Ruinen von Žovnek (Mittelslowenien). Schätzungen der Populationsgröße (N<sub>i</sub>), des Populationszuwachses (g<sub>i</sub>) und der Überlebensrate (φ<sub>i</sub>) mit Angabe der Standardfehler; Schätzwerte nach der Jolly-Seber Methode.

| Date<br>Datum | Estimate / Schätzwert |                |                | Standard error / Standardfehler |                             |                             |
|---------------|-----------------------|----------------|----------------|---------------------------------|-----------------------------|-----------------------------|
|               | N <sub>i</sub>        | g <sub>i</sub> | φ <sub>i</sub> | SE <sub>N<sub>i</sub></sub>     | SE <sub>g<sub>i</sub></sub> | SE <sub>φ<sub>i</sub></sub> |
| 07. May       | 557                   | -130           | 0.73           | 235.6                           | 434.7                       | 0.09                        |
| 17. May       | 276                   | -83            | 0.72           | 106.4                           | 141.6                       | 0.07                        |
| 24. May       | 115                   | -12            | 1.12           | 36.2                            | 52.7                        | 0.13                        |
| 04. June      | 117                   | -29            | 0.83           | 56.7                            | 33.9                        | 0.24                        |
| 13. June      | 75                    | -              | -              | 44.8                            | -                           | -                           |

Table 4: Average population size (N) and density (D) of *Podarcis muralis* in the Žovnek castle ruins (Central Slovenia), estimated by various mark-recapture based algorithms.

Tab. 4: Mittlere Größe (N) und Dichte (D) der *Podarcis muralis* Population von den Ruinen von Žovnek (Mittelslowenien); nach verschiedenen auf Fang und Wiederfang basierenden Methoden geschätzt.

| Method / Methode | N      | D (ind./100 m <sup>2</sup> ) |
|------------------|--------|------------------------------|
| Petersen         | 120    | 6                            |
| Jolly-Seber      | 75     | 3.9                          |
| Cumulative       | 95-100 | 4.8-5                        |

the forest situated between the castle ruins and the vineyard. It is possible that the decline of the "ruin" population was thus caused by the emigration of subadults into new suitable habitats. According to BENDER (1997), expansion of natural habitat can stabilize the population density of the Wall Lizard. Therefore, I suggest that the decline of the "ruin" population is probably transitory, but further research will be necessary to test this assumption.

The average population density was calculated to be 6 specimens per 100 m<sup>2</sup> (Chapman's modification of Petersen estimate) and 3.9 specimens per 100 m<sup>2</sup> (Jolly-Seber stochastic method), respectively (table 4). The average density of Wall Lizards was 0.5 specimens per 100 m<sup>2</sup> in one location in Germany (JAHNKE & al. 1980) and one specimen per 100 m<sup>2</sup> in another (HAE-

SE 1981; DEXEL 1984); thus the Wall Lizard average density was much higher in the Žovnek castle ruin than in the German sites, paralleling the situation at some French locations, where 5.3. specimens per 100 m<sup>2</sup> (BARBAULT & MOU 1986) and up to 5.6 specimens per 100 m<sup>2</sup> (BARBAULT & MOU 1988) have been found. These results are not surprising, since the climatic conditions of the Žovnek castle region are probably more similar to those of France than of Germany.

The number of adult males exceeded that of adult females (apparent sex ratio = 1.25 : 1) but the difference was not statistically significant (Yates-corrected  $\chi^2 = 0.58$ ,  $df = 1$ ,  $p > 0.05$ ). The sex ratio of the Slovenian population was similar to that observed in the northern populations, e.g. in Germany (GÜNTHER & al. 1996; SCHMIDT-LOSKE 1997), in the Netherlands (STRIJBOSCH & al. 1980) and in southern populations, e.g. in France (BARBAULT & MOU 1988). However, different sex ratios up to 1.7 : 1 and 1 : 1.6 (males : females) were estimated by BENDER & al. (1996) at isolated populations in vineyards in Germany.

The assumption that recapture probability was not significantly influenced by the toe-clipping was confirmed by Pearson's correlation coefficient ( $r = 0.51$ ).

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