

Odontometric divergence in Savi's vole Umbrian populations *Microtus savii* (de Selys-Longchamps, 1838) (Arvicolinae, Rodentia)

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Abstract

This study highlights the odontometric divergence on the first lower molar (M_1) criteria in five Umbrian *Microtus savii* populations. Poggiovalle and Forcatura, the two most geographically and climatically distant populations, differ in all the criteria studied. A west-east decrease of 0.126 mm is observed between the populations of Poggiovalle and Forcatura. The Poggiovalle population differs from the other populations by a lower length/width ratio M_1 , and the Forcatura population reports an M_1 anterior part (51.62%) higher than the Borgo Trevi population (50.65%).

Keywords: *Microtus savii*, Arvicolinae, Rodentia, Umbria, Odontometry.

Divergence odontométrique chez les populations ombriennes du campagnol de Savi *Microtus savii* (de Selys-Longchamps, 1838) (Arvicolinae, Rodentia)

Résumé

Cette étude met en évidence la divergence odontométrique sur les critères de la première molaire inférieure (M_1) dans cinq populations ombriennes de *Microtus savii*. Poggiovalle et Forcatura, les deux populations les plus éloignées géographiquement et climatiquement, diffèrent sur tous les critères étudiés. Une diminution ouest-est de 0,126 mm est observée entre les populations de Poggiovalle et Forcatura. La population de Poggiovalle se distingue des autres populations par un rapport longueur/largeur M_1 plus faible, et la population Forcatura présente une partie antérieure de la M_1 (51,62 %) plus élevée que la population de Borgo Trevi (50,65 %).

Mots clés: *Microtus savii*, Arvicolinae, Rodentia, Ombrie, Odontométrie.

Divergenza odontometrica nelle popolazioni umbre di Arvicola di Savi *Microtus savii* (de Selys-Longchamps, 1838) (Arvicolinae, Rodentia)

Riassunto

Il presente studio evidenzia la divergenza odontometrica riguardo a criteri nel primo molare inferiore (M_1) in cinque popolazioni umbre di *Microtus savii*. Poggiovalle e Forcatura, le due popolazioni più distanti dal punto di vista geografico e climatico, differiscono per tutti i criteri studiati: un decremento ovest-est di 0,126 mm viene osservato, rispettivamente, tra queste due popolazioni. La popolazione di Poggiovalle si differenzia dalle altre popolazioni per il rapporto lunghezza/larghezza di M_1 più basso, mentre la popolazione di Forcatura presenta la parte anteriore di M_1 più alta (51,62%) rispetto alla popolazione di Borgo Trevi (50,65%).

Parole chiave: *Microtus savii*, Arvicolinae, Rodentia, Umbria, Odontometria.

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Introduction

The Savi's vole was described by Selys-Longchamps (1838) under the name *Arvicola savii* from specimens collected by P. Savi in the region of Pisa (Tuscany, Italy). The systematic and taxonomic status of the Savi's vole has changed several times since its description in 1838 (Trouessart, 1910; Miller, 1912; Ellermann & Morrison-Scott, 1951; Niethammer & Krapp, 1982), and it is currently classified in the subgenus *Microtus* (*Terricola*) (Chaline *et al.*, 1988; Wilson & Reeder, 2005; Pardiñas *et al.*, 2017; Krystufek & Shenbrot, 2022).

The current geographical distribution of *M. savii* includes northern and central Italy, Ticino (southern Switzerland) and the eastern edge of the Alpes-Maritimes département (France) (Amori *et al.* 2008). In southern and central Italy, *M. savii* is replaced by *M. brachycercus*, described from Calabria by von Lehmann (1961), initially considered a subspecies and now a valid species (Galleni *et al.*, 1994, 1998; Wilson & Reeder, 2005; Bezerra *et al.*, 2015; Loy *et al.*, 2019; Krystufek & Shenbrot, 2022). However, the distribution of the two species in central Italy remains to be clarified.

In Umbria, *M. savii* occupies almost the entire region. The species has been found in 54 municipalities, with a regional distribution index of 0.33 and a municipal distribution index of 0.59 (Gaggi & Paci, 2014); it has been reported from 65 m of the Penna in Teverina (TR) (Gaggi & Paci, *op.cit.*) over 1800 m asl near Forca Viola (Parco Nazionale dei Monti Sibillini, PG-AP) (Nappi *et al.*, 2017).

Previous odontometric analyses of the first lower molar (M_1) criteria (Nappi *et al.* 2006, 2019) have highlighted significant divergences between *M. savii* and *M. brachycercus* and within *M. savii* populations; in particular, southern populations have a less developed anterior part of the M_1 and a more open anterior loop than central and northern Italian populations.

Genetic analyses carried out on Umbrian populations by Lucentini *et al.* (2023) confirmed the populations attribution to *M. savii*, showing peculiar genetic polymorphisms that could be due either to the wide sampling area represented by the owls' hunting grounds, or the recent evolutionary history of the populations analysed.

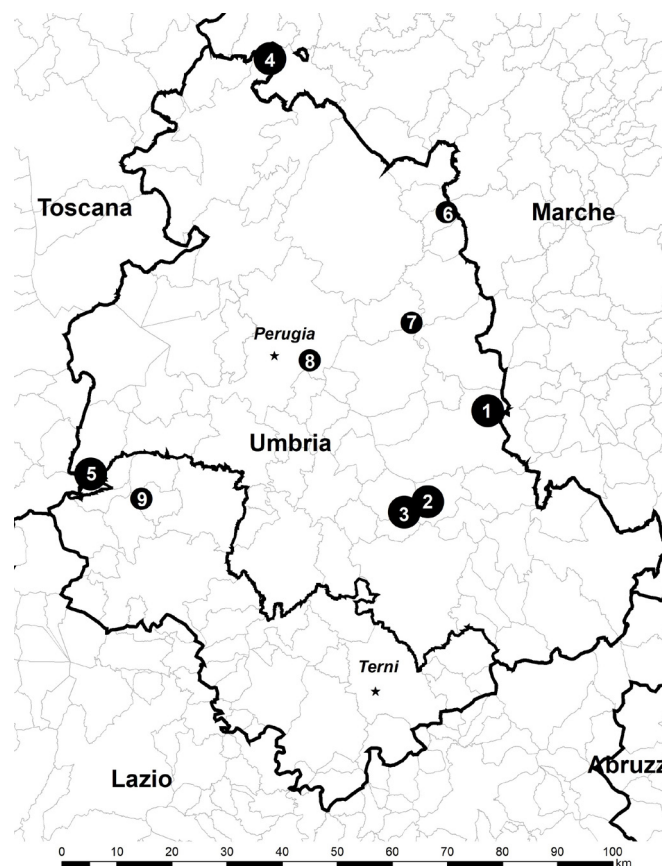


Fig. 1 - Geographical localisation of *Microtus savii* populations.

Main populations: 1-Forcatura (Foligno, province of Perugia), 2-Borgo Trevi (Trevi, province of Perugia), 3-Madonna della Stella (Montefalco, province of Perugia), 4-Scalocchio (Città di Castello, province of Perugia) and 5-Poggiovalle (Fabro, province of Terni).

Secondary populations: 6-Sigillo (province of Perugia), 7-Montemezzo (Valfabbrica, province of Perugia), 8-Ansa degli Ornari (Perugia, province of Perugia) and 9-Case Cola (Parrano, province of Terni).

The inclusion of new populations allows to improve the knowledge of the odontometric variation of this species at the Umbrian scale and to propose new multidisciplinary studies.

Material and method

The material studied came from (Fig. 1):

a) five main populations: 1-Forcatura (Foligno, province of Perugia) N=176 M_1 , 2-Borgo Trevi (Trevi, province of Perugia) N=81 M_1 , 3-Madonna della Stella (Montefalco, province of Perugia) N=150 M_1 , 4-Scalocchio (Città di Castello, province of Perugia) N=116 M_1 and 5-Poggiovalle (Fabro, province of Terni) N=362 M_1 ;

b) four secondary populations: 6-Sigillo (province of Perugia) N=30 M_1 , 7-Montemezzo (Valfabbrica, province of Perugia) N=17 M_1 , 8-Ansa degli Ornari (Perugia, province of Perugia) N=18 M_1 and 9-Case Cola (Parrano, province of Terni) N=20 M_1 .

According to Orsomando *et al.* (1999), the localities studied are characterised by the following bioclimatic schemes: Poggiovalle: submediterranean hills, temperate variant; Scalocchio: high hills, humid variant; Madonna della Stella: low-hills; Borgo Trevi: low-hills, humid variant; Forcatura: low-mountain, humid variant; Case Cola: low-hills; Sigillo: high-hills, humid variant; Valfabbrica: high-hills; Ansa degli Ornari: low-hills.

Descriptive analysis was performed on main and secondary populations, and comparative analysis was performed on the main populations only (insufficient sample size for statistical comparison in secondary populations).

Comparative analysis was performed using the following M1 criteria (Brunet-Lecomte, 1990; Brunet-Lecomte *et al.*, 2010) (Fig. 2): total length = measure 6, anterior part = (measure 6-measure 3)/measure 6 x 100, closure of anterior loop = (measure 20-measure 18)/measure 21 x 100 and length/width ratio = measure 6/measure 21.

Results

The results of the descriptive and statistical analyses are shown in **Tabl. 1** and **Fig. 3**.

Discussion and conclusion

Poggiovalle and Forcatura, the most geographically and climatically distant populations, differ on all criteria. For the total length, a west-east decrease of 0.126 mm is observed between the populations of Poggiovalle (2.695 mm) and Forcatura (2.569 mm). Furthermore, the population of Poggiovalle differs from the other populations by a lower length/width ratio M_1 . The population of Poggiovalle also differs from the population of Forcatura by a less developed anterior part.

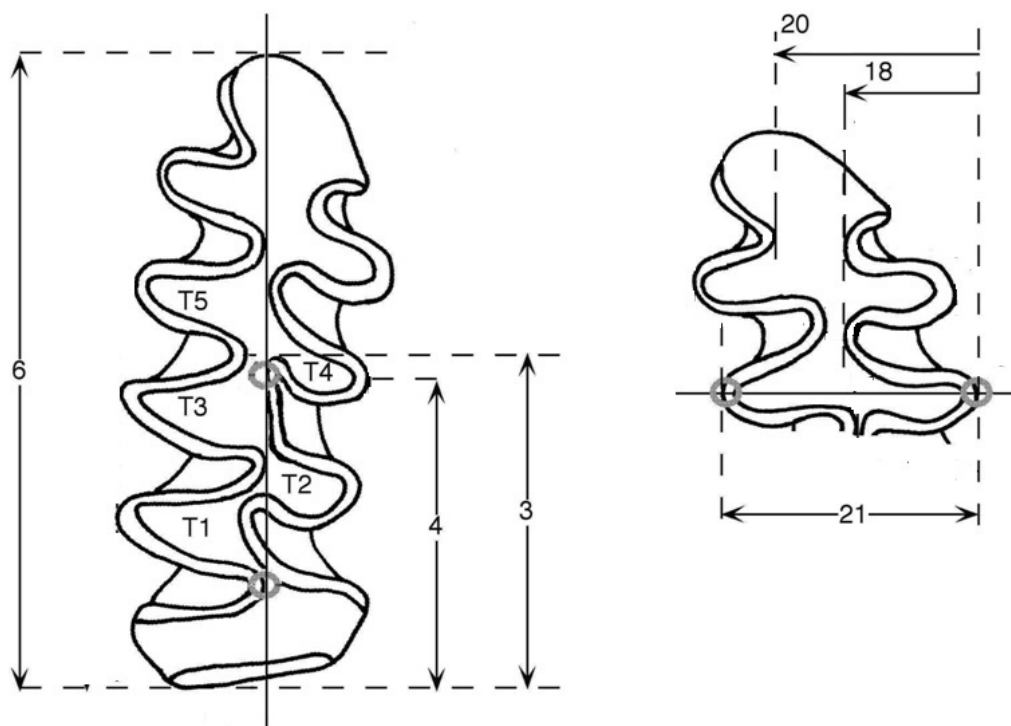


Fig. 2 - Morphometry of the first lower molar of *Microtus (Terricola) species*. Six measures taken (in mm), labelled 3, 4, 6, 18, 20 and 21.

The main populations were compared using one-way analysis of variance (ANOVA). In the event of a significant population effect, the analysis was supplemented by a multiple Bonferroni comparisons test to determine precisely between which populations a significant difference was observed.

Criteria		Total length (mm)	Anterior part (%)	Anterior loop (%)	Length/width (ratio)
ANOVA		p<0.0001	p<0.0001	p<0.0001	p<0.0001
Population	N	Mean±Standard deviation Bonferroni test : Means with same letter are not significantly different (p≥0.05)			
Forcatura	176	2.569±0.124 C	51.62±1.39 C	26.30±6.32 A	2.701±0.138 B
Borgo Trevi	81	2.600±0.096 B C	50.65±1.33 A	26.82±7.63 A	2.713±0.135 B
Madonna della Stella	150	2.604±0.096 C	51.20±1.21 B	25.03±7.59 A B	2.734±0.125 B
Scalocchio	116	2.649±0.122 B	51.13±1.19 A B	22.53±7.32 C	2.714±0.132 B
Poggiovalle	362	2.695±0.141 A	50.74±1.31 A	24.26±6.42 B C	2.658±0.139 A
		Mean±Standard deviation (no comparison performed)			
Sigillo	30	2.599±0.102	50.653±1.452	25.439±7.505	2.708±0.116
Montemezzo	17	2.619±0.136	51.237±1.457	17.217±8.076	2.698±0.107
Ansa degli Ornari	18	2.705±0.109	50.923±1.404	20.859±5.356	2.773±0.146
Case Cola	20	2.752±0.127	50.883±1.090	27.098±6.220	2.691±0.163

Tabl. 1 - Description of first lower molar criteria in Umbrian *Microtus savii* populations.

ANOVAs showed that the populations were significantly different (p<0.0001) for all criteria. Significant differences between *M. savii* populations according to the Bonferroni test were as follows:

- 1) the total length is greater in the Poggiovalle population (2.695±0.141 mm) than in the Scalocchio, Madonna della Stella, Borgo Trevi and Forcatura populations (2.649±0.122 mm, 2.604±0.096 mm, 2.600±0.096 mm and 2.569±0.124 mm, respectively);
- 2) the anterior part is less in the Borgo Trevi and Poggiovalle populations (50.65% and 50.74±1.31%, respectively) than in the Madonna della Stella and Forcatura populations (51.20±1.21% and 51.62±1.39%, respectively);
- 3) the anterior loop is more open in the Borgo Trevi and Forcatura populations (26.82±7.63% and 26.30±6.32%, respectively) than in the Poggiovalle and Scalocchio populations (24.26±6.42% and 22.53±7.32%, respectively);
- 4) the length/width ratio is lower in the Poggiovalle population (2.658±0.139) than in the Forcatura, Borgo Trevi, Scalocchio and Madonna della Stella populations (2.701±0.138, 2.713±0.135, 2.714±0.132 and 2.734±0.125, respectively).

The population of Scalocchio differs from the other populations of the province of Perugia (Madonna della Stella, Borgo Trevi and Forcatura) by a more closed anterior loop.

Compared to the means found in central Italy by Nappi *et al.* (2019), the population of Poggiovalle is characterised by a greater total length (2.695 versus 2.552 mm), while that of Forcatura is similar (2.569 mm).

The populations of Forcatura, Madonna della Stella and Borgo Trevi are close, except for the anterior part, especially between Forcatura and Borgo Trevi, for which a difference of 0.97 % (51.62 % - 50.65 %) is found. The anterior part of the population of Borgo Trevi is smaller than that reported for central Italy by Nappi *et al.* (2019) (51.33%).

For populations with sample sizes estimated to be insufficient for relevant statistical analysis, the following should be noted:

The population of Case Cola (N=20), near Poggiovalle, has a high total length (2.752±0.127 mm), as in

Poggiovalle, while the length/width ratio of M₁ is lower (2.691±0.163 mm), similar to those observed in the populations of the province of Perugia;

In the population of Sigillo (N=30), the anterior part of the M₁ (50.65%) is closer to that of Borgo Trevi (more distant) than to that of Scalocchio (less distant);

The population of Montemezzo (N=17) has a close anterior loop (17.22±8.08%) and Ansa degli Ornari (N=18) is characterised by a large total length (2.705±0.109 mm).

None of the 3 populations with a high M₁ length (Poggiovalle, Case Cola and Ansa degli Ornari) has a humid bioclimatic scheme. Among the populations with a humid bioclimatic scheme (Scalocchio, Borgo Trevi, Forcatura and Sigillo), the development of the anterior part is moderate (Borgo Trevi and Sigillo) or medium (Scalocchio and Forcatura) and the closure of the anterior loop is medium (Scalocchio) or moderate (Borgo Trevi, Forcatura and Sigillo).

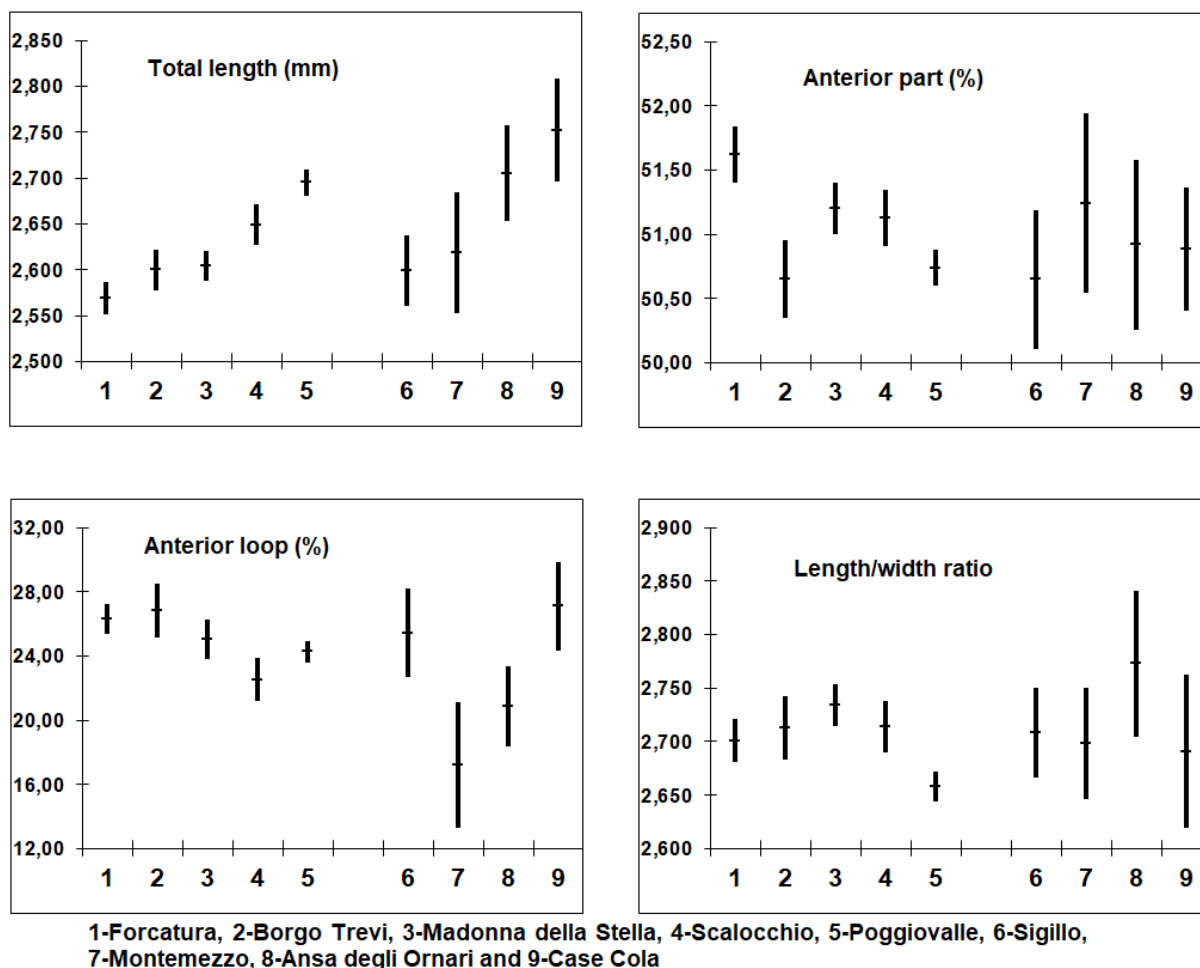


Fig. 3 - Mean \pm 2*SEM of first lower molar criteria in Umbrian *Microtus savii* populations. N: sample size. SEM: standard error of the mean, SEM = standard deviation / square root (N).

The results obtained show the interest of a genetic study, focused in particular on the Poggiovalle and Forcatura populations, as already carried out by Lucentini *et al.* (2023) on the Madonna della Stella population.

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