

PRELIMINARY ANALYSIS OF THE FIRST LOWER MOLAR VARIABILITY IN LATE PLEISTOCENE AND LIVING POPULATIONS OF *TERRICOLA SAVII* (ARVICOLIDAE, RODENTIA)

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With 7 figures and 3 tables

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Abstract

The main object of this research is the study of the variability degree of the first lower molar in Late Pleistocene and living populations of *Terricola savii* in Italy (whose conspecificity has been proved by genetic analyses) and its comparison with that of fossil populations (assigned to *T. savii* on a morphological basis) in order to find a way to attribute isolated fossil remains to specific systematic groups. On this basis, we attempted to establish, through different analyses and direct observations on the occlusal dental surface morphology, the relationships that exist between fossil and living populations, and to verify the existence of a temporal and/or geographic cline.

Introduction

Terricola savii (DE SELYS LONGCHAMPS, 1838) (Arvicolidae, Rodentia) is the most common living vole on the Italian peninsula (south of the Apennines) and it is common in northern Italy too (between the Alps and the Apennines). During the Late Pleistocene *T. savii* colonized Sicily (Petrucci, 2002). Voles classified as *T. gr. T. savii* are present in Early Toringian mammal assemblages (San Giovanni di Duino, Venezia Giulia - Campani Quarry, Tuscany - Case Picconetto, Abruzzi) (Bartolomei, 1976; Marcolini, 2002; Marcolini *et al.*, 2003) belonging to the Fontana Ranuccio Faunal Unit (Gliozzi *et al.*, 1997). True Savi's ground voles are reported since the beginning of Late Toringian (Bartolomei, 1980), corresponding to the latest phase of the Middle Pleistocene. During the Late Pleistocene the geographic range of *T. savii* expanded or reduced due to climatic changes. During the temperate-warm oscillations, this species reached the Alpine region, whilst during the cool or cold periods, it was restricted to the southern and central parts of the Italian peninsula (Kotsakis *et al.*, 2003).

Studies on local populations of *T. savii* have been carried out by several authors: De Giuli (1983), Corridi (1987), Rustioni *et al.* (1994), Abbassi & Brunet-Lecomte (1997), Masini & Abbazzi (1997), Ronchitelli *et al.* (1998). A general analysis of fossil and living populations of Italian ground voles has been already published by Brunet-Lecomte *et al.* (1994a). The present study focuses on the comparison of living and fossil populations of *T. savii* only. Our target is to examine the relationships of recent populations of central and southern areas of the Italian peninsula with the fossil ones of the same area. A similar work was performed by Brunet-Lecomte *et al.* (1994b) for *Terricola gerbei* (Gerbe, 1879) (= *Terricola pyrenaica* (de Selys Longchamps, 1847)) of northern Spain and south-western France.

Materials and Methods

The studied samples are derived from 11 localities. Five out of this number are fossil populations, while six belong to living samples. The latter are



Fig. 1: Geographical location of the studied populations.

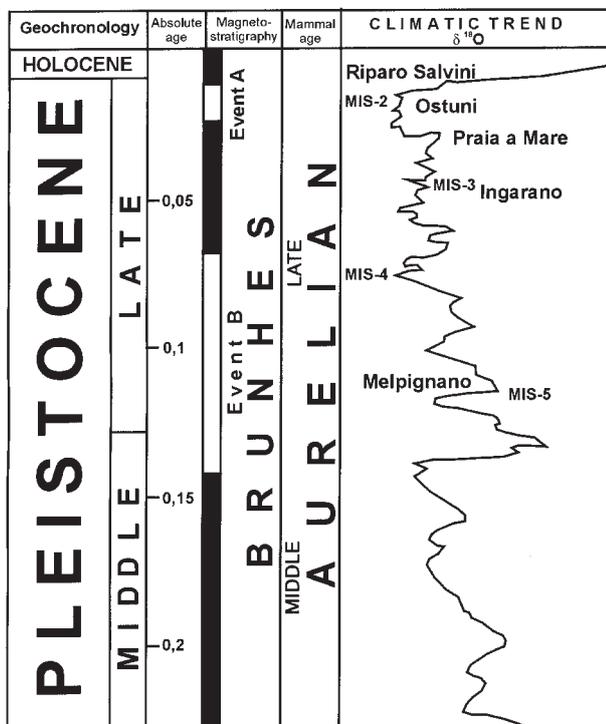


Fig. 2: Chronostratigraphy of the late Middle Pleistocene and Holocene.

from: Cervia (Ravenna, Emilia Romagna), Civitella del Tronto (Teramo, Abruzzi), Torraccia di San Gennaro (Rome, Latium), Casarano (Lecce, Apulia), Sila National Park (Calabria), Noto (Syracuse, Sicily). The five fossil populations were collected in Melpignano (Lecce, Apulia), Ingarano (Foggia, Apulia), Praia a Mare (Cosenza, Calabria), Ostuni (Foggia, Apulia) and Riparo Salvini (Latina, Latium) (fig. 1).

As to the fossil localities, in the fossiliferous site of Melpignano a fauna testifying warm climatic conditions has been recognized. In particular the macrofauna collected in sediments of karst cavities allowed its attribution to MIS 5a-5c (Bologna et al., 1994). Petronio et al. (1996) assigned the assemblage from Ingarano to the middle part of MIS 3. Capasso Barbatto & Gliozzi (2001) assigned the small mammal assemblage from Praia a Mare to the final phase of MIS 3. The Ostuni fossil assemblage is ascribed to MIS 2 by Angelone et al. (2004). The fauna from Riparo Salvini has been ascribed to the latest Pleistocene (Tardiglacial - final phase of MIS 2) (Cassoli & Guadagnoli, 1987; Alessio et al., 1993) (fig. 2).

The material studied in this research pertains to public and private collections. In particular the fossil material from Melpignano and Ingarano is stored in the Dipartimento di Scienze della Terra of the University of Rome „La Sapienza“, the fossils from Praia a Mare, Ostuni and Riparo Salvini are stored in the Laboratory of Palaeontology of the Dipartimento di Scienze Geologiche of the University Roma Tre. The recent material belongs to the „Contoli Collection“ and it is stored in the Dipartimento di Biologia Animale e dell'Uomo of the University of Rome „La Sapienza“.

The decision to take dental measurements, particularly on the first lower molars (M_1) (fig. 3b; tabs. 2, 3) is necessary because the systematics of the Arvicolidae is based on the morphology of this tooth, and because teeth are often the only common fossil elements available. Quantitative and qualitative analyses have been carried out on the studied material. The pictures of teeth were taken by using a digital camera Nikon Coolpix 995 connected to a stereoscopic microscope Nikon SMZ-U. The measurements were carried out with the graphic program CorelDraw 8. The statistic analyses were carried out with the program KyPlot ver.2.0 beta 15. Some illustrations have been produced with the aid of a Leica L2 camera lucida and of a graphical tablet.

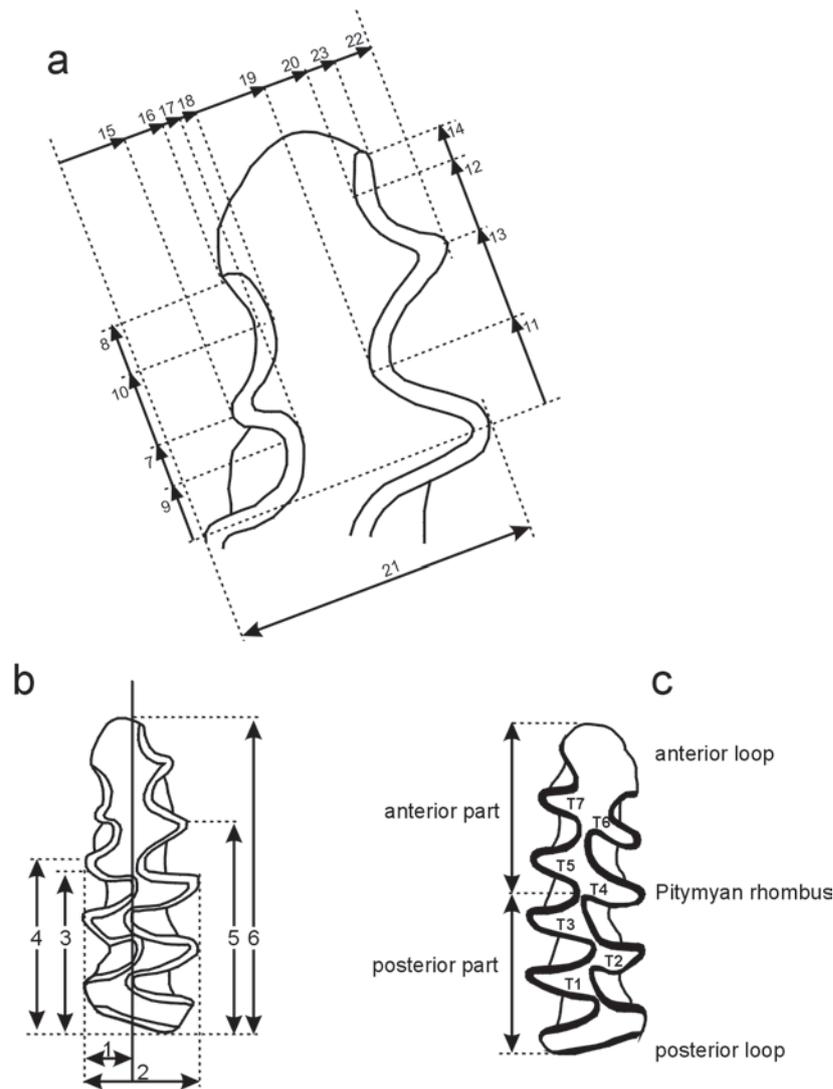


Fig. 3 : Morphology of M1 of the ground vole *Terricola savii*: a-b) morphometry of *Terricola* M1 using 23 measures; c) M1 showing the characteristic apomorphy of the group, the Pitymyan rhombus, the length of the tooth and the anterior loop (Brunet-Lecomte & Chaline, 1992).

Qualitative analyses were carried out in order to recognize the dominant morphotype of each population. In a second step 23 measurements were taken on the occlusal surface and some indices were calculated, following the methods described by Meulen (1973), Brunet-Lecomte (1990) and Marcolini (2002) (fig. 3a,c): A/L: $(\text{var6}-\text{var3}) / \text{var6} * 100$; W/L: $(\text{var2}/\text{var6})$; W2/L: $(\text{var21}/\text{var6})$; RP: $(\text{var4}-\text{var3}) / \text{var6} * 100$ (fig. 3a,c).

These ratios give the relationship between the length, the width, the curvature degree of the tooth and the development stage of the Anteroconid Complex (ACC) (Meulen, 1973), respectively.

Moreover multivariate statistical analyses, Principal Component Analysis (PCA) and Canonical Discriminant Analysis (CDA), were performed on the measurements indicated by Brunet-Lecomte (1990) and on the indices proposed by Meulen (1973); anyway it has to be underlined that these last ones were calculated on measurements taken following the method of Brunet-Lecomte (1988). Several comparisons, with the aid of the previously mentioned statistical methods were made in order to focus on the differences and/or the affinities between the analyzed populations and the variability within a single population. Both in the Canonical

Discriminant Analysis and in the Principal Component Analysis the populations were analyzed in a first moment all together. Subsequently, these same analyses (PCA and CDA) have been repeated dividing the populations in fossil and recent ones and all populations have been compared pair by pair. In all tests an outgroup was present. The outgroup population comes from the lower level of Gran Dolina (Atapuerca, Burgos, Spain) and it is composed by *Terricola arvalidens* (Cuenca - Bescos et al., 1995). This material has been found in a karst filling sediment (approximately 18 meters thick) partly ascribed to Early Pleistocene and partly to Middle Pleistocene. This population is not temporally or geographically related to ours (both living and fossil), nevertheless shows similar characteristics to those of the studied populations and for this reason has been included in the analyses.

The matrix used for PCA and CDA are available in the site <http://host.uniroma3.it/laboratori/paleontologia>.

Results

Three different morphotypes were identified, on the basis of the number of salient and re-entrant angles, of the complication and development of the

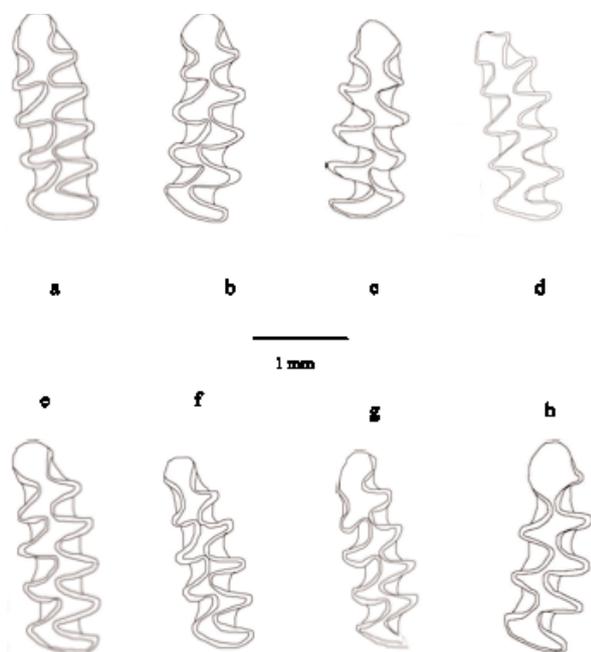


Fig. 4: Morphotypes of *Terricola savii*: a,b,c) morphotype 1 (morphotype *savii* s.s.); d,e,f) morphotype 2; g,h) morphotype 3.

Anterior Loop (AL) and of the greater or smaller confluence of the triangles in the Anteroconid Complex.

MORPHOTYPE 1 (morphotype *savii* s.s.) is characterized by a simple and wide anterior loop, with a wide neck and widely confluent with the triangles T7 and T6. T5 and T4 are broadly confluent. The reentrant angles are quite marked and slightly more flattened on the lingual side (fig. 4 a,b,c).

The anterior loop in MORPHOTYPE 2 is more complex than in morphotype 1. T7 and its reentrant angle are much more evident while T6 and its reentrant angle are only outlined or even absent. T4 and T5 are not confluent and consequently the pitymyan rhombus is not clearly visible (fig. 4 d,e,f). The anterior loop of MORPHOTYPE 3 is as simple as in morphotype 1 although the triangles are rather irregular in shape (fig. 4 g,h).

The analysis of the morphotypes shows a clear dominance of morphotypes 1 and 2 in all the examined populations, both fossil and recent, while morphotype 3 is present only marginally in the recent populations (tab.1).

As to the variability of the M_1 's within the analyzed populations, as it is shown by the qualitative data, it is clear that M_1 follows a mosaic model composed by the Anteroconid Complex (ACC), which is more variable and characterizing most of the morphotypes and by a more conservative Talonid-Trigonid Complex (TTC). The observed variability is both inter- and intra-populational. Moreover, it was possible to divide all the analyzed M_1 into two different morphotypes of both the fossil populations and the living ones (the third morphotype is present as we have seen only in the living populations with low percentages) and, in both cases, the percentages of the morphotypes are similar. Nearly none of the performed PCA have brought statistically significant results. In the plots obtained by statistically significant analyses there seem to be no differences within the fossil populations or the recent ones. And there seem to be no differences between fossil and living populations.

As to the living populations, differences have been recognized between the populations of Noto (Siracusa, Sicily) and Cervia (Ravenna, Emilia Romagna), but this is a rather obvious result, being geographically the two farthest populations within those considered. Moreover, the population of Noto, coming from the island of Sicily, introduces

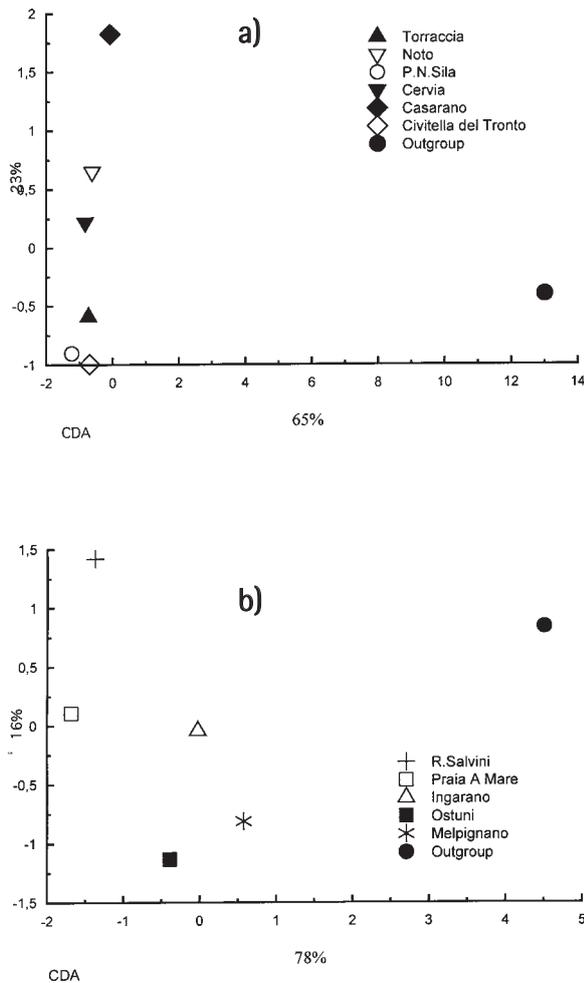


Fig. 5: On the diagram axis are plotted the scores of canonical variables resulting from the Discriminant Canonical Analysis. The two selected variables are those with the higher eigenvalues. The percentages reported along each axes are the explained variances of the variable taken into consideration. a) Projection of the centroids of fossil populations of *T. savii*; b) Projection of the centroids of living populations of *T. savii*.

all those problems which are typical of insular populations (Petrucci, 2002).

From the quantitative analyses conducted with CDA, some differences are evident between the two groups (fossil and living populations); the affinity and homogeneity degree within the fossil populations (heterochronic) (fig. 5a) turns out to be smaller with respect to the living populations (homochronic) (fig. 5b).

From CDA the following observations can be made:

a) The fossil Apulian populations (Melpignano, Ingarano, Ostuni) and the living Apulian population (Casarano) differ in a sensitive way from the other analyzed populations (fig. 6), particularly from the Calabrian ones (Praia a Mare and Sila National Park). The Calabrian fossil (Praia a Mare) and living (Sila National Park) populations, on the other hand, seem to be different from the other elements pertaining to the same group (fig.7). The Apulian populations, both recent and fossil, show a large affinity, allowing to hypothesize the provenience of present-day demes phylogenetically connected with palaeodememes of the same geographic area, from MIS 5a-5c up to the present (fig. 2). Moreover, it is evident that the population of Melpignano (MIS 5a-5c) is the farthest from the living populations, followed by that of Ingarano, confirming consequently the biochronologic attribution of these fossil populations, obtained by means of the study of the entire faunal assemblages. The fossil populations of Ingarano (MIS 3) and Ostuni (MIS 2), and the living one from Cassarano have a similar position on the horizontal axis, but the living population is on a distinct position on the vertical axis (fig. 6).

b) There are some limits in the measurement method proposed by Brunet-Lecomte, since such measurements do not take in particular account the anterior loop, neglecting what has turned out to be the more variable morphologic feature in the qualitative analysis.

The morphologic/morphotypic variability of the fossil populations fits that of the recent populations (whose attribution to the same species is certain,

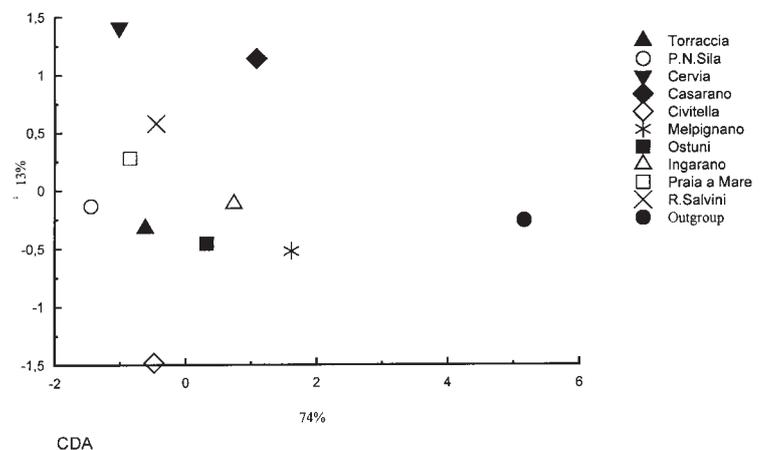


Fig. 6: Projection of the centroids of both fossil and living populations of *T. savii*.

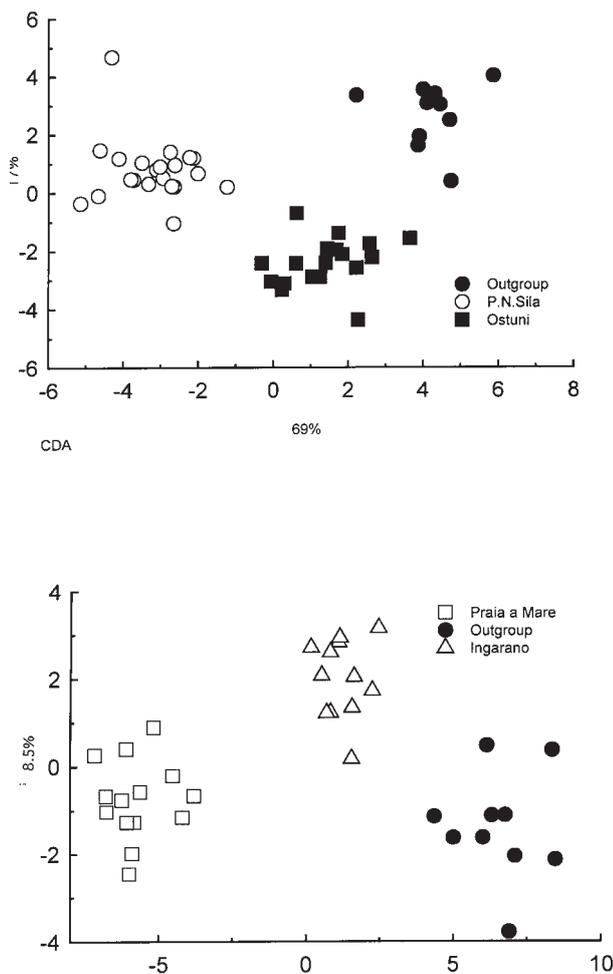


Fig. 7: Comparison between Apulian and Calabrian populations of *T. savii*.

thanks to genetic analyses), therefore confirming the correct attribution of the fossil populations to the species *T. savii*.

Conclusions

PCA is not conclusive as the obtained results are not statistically significant and it is impossible to distinguish any important difference between the eleven studied populations. However, this datum confirms the attribution of all the material to the same species, because this kind of analysis clearly separates different species.

The differences obtained from the CDA demonstrate that the variables of the adopted measurements set (used in Europe since the end of the

eighties for the systematic studies of the family Arvicolidae), can differentiate populations of different species and, in a more limited way, populations of the same species.

The analysis of the fossil population from Praia a Mare and the living one from Sila National Park does not give any hint about the existence of *Terricola brachycercus* (LEHMANN, 1961), an endemic Calabrian species whose sympatric coexistence with *Terricola savii* has been proved by genetic studies (Galleni, 1995; Galleni et al., 1998 and references therein). This discrepancy can be probably explained by the absence of *T. brachycercus* from the analysed sample as *T. brachycercus* has a very restricted distribution area and is sympatric with *T. savii*. Nevertheless, Nappi et al. (2003) recognised differences between some Calabrian populations and *T. savii*.

T. savii ground voles from Apulia, both fossil and living ones, are rather homogeneous and differ from other populations (fossil and living) of the species. Apulia probably acted as a refuge area during the cold oscillations of the Late Pleistocene. Moreover geomorphological landscape (and consequently environmental) differences between Apulia and the Tyrrhenian side of the Peninsula influenced the morphological divergence of the Apulian populations. Pioneers of *T. savii* from this region re-colonized the Adriatic side of the Italian peninsula during the Holocene.

The populations from the Tyrrhenian side of Italy, Praia a Mare (MIS 3), Riparo Salvini (Tardiglacial, latest MIS 2), Sila National Park and Torraccia are very similar and differences between fossil and living populations are minimal. On the western (warmer) side of the Peninsula, *T. savii* survived during the later part of the Late Pleistocene and was almost isolated from the Apulian populations.

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	Morphotype 1	Morphotype 2	Morphotype 3	Total number
MELPIGNANO	66.67	33.33	0	18
INGARANO	66.67	33.33	0	12
PRAIA A MARE	71.43	28.57	0	14
OSTUNI	68.42	31.58	0	19
R. SALVINI	77.78	22.22	0	16
CERVIA	79.49	20.51	0	39
CIVITELLA	72.41	24.14	3.45	29
TORRACCIA	61.54	30.77	7.69	26
CASARANO	77.42	19.35	3.23	31
P.N.SILA	80.95	14.29	4.76	21
NOTO	59.46	37.94	2.60	37

Tab. 1: Percentages of the morphotypes for each population of *T. savii*.

	N° of specimens	Minimum	Maximum	Mean	Standard deviation v6
MELPIGNANO	18	2.29	2.92	2.57	0.18
INGARANO	12	2.51	2.77	2.66	0.08
PRAIA A MARE	14	2.32	2.7	2.55	0.12
OSTUNI	19	2.5	2.79	2.65	0.18
R. SALVINI	16	2.43	3.06	2.6	0.27
CERVIA	39	2.28	2.85	2.59	0.12
CIVITELLA	29	2.21	2.87	2.55	0.15
TORRACCIA	26	2.45	3.25	2.74	0.19
CASARANO	31	2.53	2.91	2.68	0.14
N.P.SILA	21	2.36	3.02	2.66	0.2
NOTO	37	2.38	2.8	2.54	0.1

Tab. 2: Length of M_1 of *T. savii*.

	N° of specimens	Minimum	Maximum	Mean	Standard deviation v21
MELPIGNANO	18	0.86	1.03	0.92	0.05
INGARANO	12	0.91	1.08	0.99	0.05
PRAIA A MARE	14	0.82	0.97	0.92	0.04
OSTUNI	19	0.88	1.01	0.92	0.05
R. SALVINI	16	0.83	1.19	0.99	0.09
CERVIA	39	0.7	1.11	0.93	0.07
CIVITELLA	29	0.84	1.06	0.94	0.07
TORRACCIA	26	0.9	1.16	1.01	0.08
CASARANO	31	0.87	1.09	0.98	0.05
N.P.SILA	21	0.85	1.16	0.99	0.09
NOTO	37	0.84	1.02	0.95	0.04

Tab. 3: Width of M_2 of *T. savii*.

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