Microtus (Tyrrhenicola) sondaari n. sp. (Arvicolidae, Rodentia) from Monte Tuttavista (Sardinia, Italy)*

Federica Marcolini[1], Caterinella Tuveri[2], Marisa Arca & Tassos Kotsakis[3]

[1] *Federica Marcolini, Dipartimento di Scienze della Terra, Università di Pisa, Via Santa Maria 53 — 56126 Pisa, Italia.*
[2] *Marisa Arca, Caterinella Tuveri, Soprintendenza Archeologica per le Province di Sassari e Nuoro, Via Ballero, 30 – 08100, Nuoro, Italia.*
[3] *Tassos Kotsakis, Dipartimento di Scienze Geologiche, Università Roma Tre, Largo San Leonardo Murialdo 1 — 00146 Roma, Italia.*
e-mail: fmarcolini@dst.unipi.it

ABSTRACT: *Microtus (Tyrrhenicola) henseli* is an endemic fossil vole widespread in Sardinia and Corsica during Middle Pleistocene to Holocene.

Some analyses on new populations of *M. (Tyrrhenicola)* from the recently studied fissure fillings of Monte Tuttavista (Orosei, Western Sardinia) have been carried out, leading to the description of a new species of *M. (Tyrrhenicola)* more archaic than *Microtus (Tyrrhenicola) henseli*.
Key-words: *Arvicolid, rodent, Sardinia, Middle Pleistocene, systematics*.

ΠΕΡΙΛΗΨΗ: O *Microtus (Tyrrhenicola) henseli* είναι ένα απολιθωμένο ενδημικό τρωκτικό σύνηθες στη Σαρδηνία και την Κορσική από το Μέσο Πλειστόκαινο στο Ολόκαινο.

Οι αναλύσεις που πραγματοποιήθηκαν σε νέους πληθυσμούς του *M. (Tyrrhenicola)* από τα πρόσφατα μελετηθέντα χάσματα της Monte Tuttavista (Orosei, υτική Σαρδηνία) οδήγησαν στην περιγραφή ενός νέου είδους του *M. (Tyrrhenicola)* με πιο αρχαϊκούς χαρακτήρες από το *Microtus (Tyrrhenicola) henseli*.
Λέξεις-κλειδιά: *Arvicolid, τρωκτικό, Σαρδηνία, Μέσο Πλειστόκαινο, συστηματική ταξινόμηση.*

INTRODUCTION

The genus *Tyrrhenicola* has been instituted by FORSYTH MAJOR in 1905 to describe the insular fossil vole remains coming from Corse and Sardinia discovered by CUVIER in 1823 and is now considered a subgenus of *Microtus*; though considering it at a subgeneric level, for a purpose of simplicity from now on it will be called just *Tyrrhenicola*. *Tyrrhenicola* (Arvicolidae, Rodentia, Mammalia) is an endemic fossil vole widespread in Sardinia and Corsica during Middle Pleistocene to Holocene with the only species *Tyrrhenicola henseli*. Though different evolutionary degrees have been recognised between different populations of *T. henseli* (MEZZABOTTA *et al.*, 1996), the systematic position and the phylogenetic relationships of *Tyrrhenicola* are still controversial.

After the institution of the new genus *Tyrrhenicola* by FORSYTH MAJOR, CHALINE (1972) following the considerations of HINTON (1926) not only suggested that it represented an insular differentiation of *Terricola*, because of its skull features and the presence of a pitymyan rhombus in the first lower molars, but also that it belongs to the same subgenus *Microtus (Terricola)* and proposes an evolution from some *Allophaiomys* forms like the other *Terricola*.

On the contrary VAN DER MEULEN (1973) and RABEDER (1981) believe the similarities with *Terricola* to be only a parallelism and propose an evolution from *Allophaiomys pliocaenicus*, suggesting an immigration to Sardinia during Early Pleistocene.

Later on BRUNET-LECOMTE & CHALINE (1990) further suggest that *Tyrrhenicola henseli* may represent an archaic branch of the Mediterranean group of *Terricola* they suppose to be derived from an evolved form of *Allophaiomys*, *A. chalinei* that might have reached Sardinia and Corse during the early Middle Pleistocene.

MINIERI *et al.* (1995) recognise several morphotypes in first lower molars and third upper molars of the Late Pleistocene Cava Alabastro (Is Oreris, Sardinia) and suggest an evolution from *A. ruffoi* from the Italian Late Villafranchian.

MEZZABOTTA *et al.* (1996), on the basis of some morphometric analyses, propose an evolution from the *Allophaiomys ruffoi-burgondiae* group and an immigration

* O *Microtus tyrrhenicola sondaari* n. sp. (Arvicolidae, Rodentia) από το Monte Tuttavista (Σαρδηνία, Ιταλία).

event dated late Early or early Middle Pleistocene throughout the Tuscan archipelago.

All the *Tyrrhenicola* populations recovered until a few years ago in Sardinia or Corsica seem to be already evolved, none of them presenting archaic features that could help us in correlating with continental species.

Anyway, first BRANDY (1978), later on CORDY (1997) and SONDAAR (2000), studying the remains from Capo Figari and of quarry X g3 of Monte Tuttavista (Sardinia), recognised the presence of a small sized form of *Tyrrhenicola*, more archaic than those recovered before. Such a possibility has been indeed confirmed by MARCOLINI *et al.* (in press) where many signs indicate a marked difference between quarry X g3 and other *Tyrrhenicola* populations from the recently studied fissure fillings of Monte Tuttavista, among which quarry X g3 (ROOK *et al.*, 2003; ABBAZZI *et al.*, 2004).

The studied populations show different morphotype distributions that allowed to recognise differences in evolutionary degrees. The comparison of quarry X g3 *Tyrrhenicola* with all the other populations of nearby quarries (MARCOLINI *et al.*, in press) confirms this population is very archaic and much more simple than the populations up to day studied, allowing the definition of a new species.

MATERIALS AND METHODS

Monte Tuttavista (836 m a.s.l., Orosei, Nuoro) is located in the Northeastern side of Sardinia (Fig. 1), is part of a massif of mesozoic limestones and on its flanks on an area less the 3 km^2 numerous limestone quarries are active. Thanks to the collaboration between the Soprintendenza per i Beni Archeologici delle Province di Sassari e Nuoro and the quarries owners, it has been possible to recover the bony breccias filling of these calcareous fissures first discovered by Mr. G. MELE in 1995 (CORDY, 1997; ABBAZZI *et al.*, 2004). Both large and small mammals, as well as amphibians, reptiles and birds have been recovered and more than 80.000 specimens have been collected. They can be ascribed to four different faunal complexes, ranging in time from the Late Pliocene to the Late Pleistocene (PALOMBO *et al.*, 2003; ROOK *et al.*, 2003; ABBAZZI *et al.*, 2004). In the present paper results will be presented about the *Tyrrhenicola* remains coming from quarry X g3 that have also been compared to those of the other fissure fillings of Monte Tuttavista: quarry VI banco6, IX prolago, XI g3, XI canide, XI "dic. 2001", XI rondone.

Hundreds of *Tyrrhenicola* specimens were present in each quarry, but a sample of about 30 to 40 first lower molars *per* quarry have been chosen. They have been described and attributed to the main morphotypes recognized by MEZZABOTTA *et al.* (1996) and frequency percentages have been calculated for each quarry. Statistical analyses have been performed on twenty-three different measurements taken on the occlusal surface of M_1s (Fig. 2; MARCOLINI *et al.*, in press), moreover an analysis of enamel thickness on some populations have been carried out using the SDQ index (HEINRICH, 1978). The SDQ index corresponds to the ratio of the enamel thickness of the posterior part of the triangles compared to

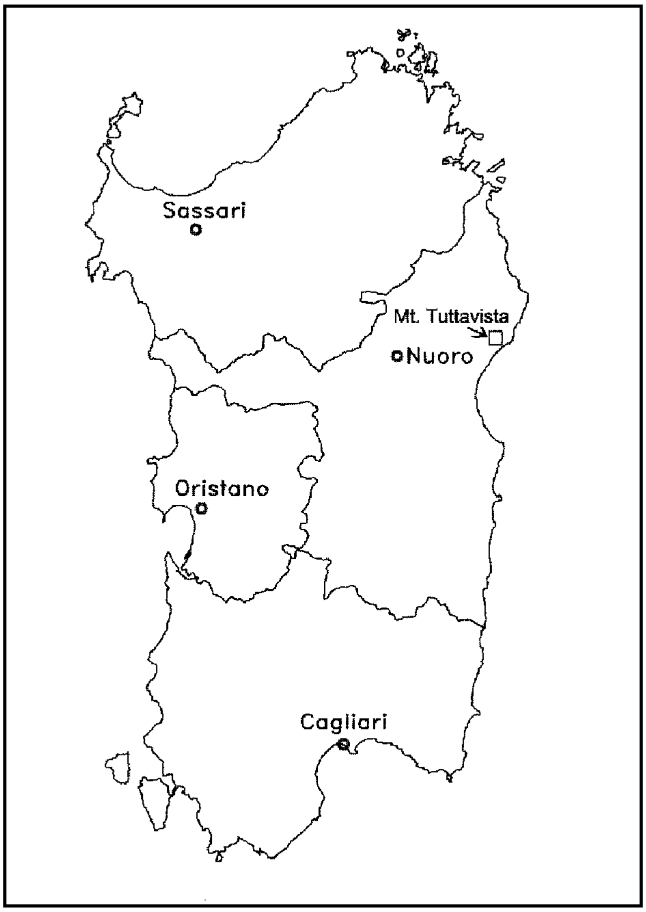


Fig. 1. Localisation of Monte Tuttavista quarries.

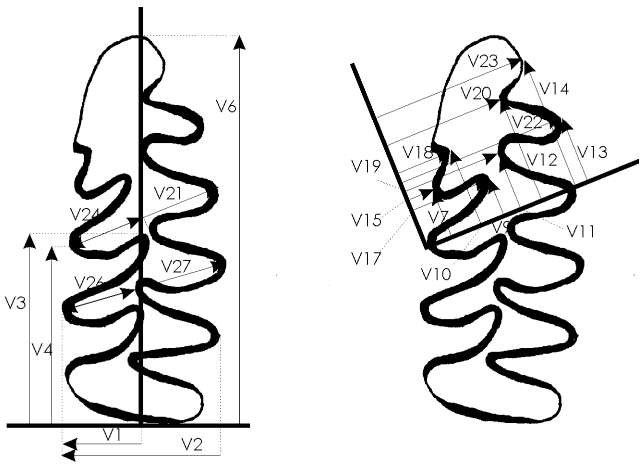


Fig. 2. Main measurements taken on the occlusal surface of *Tyrrhenicola* M_1, from MARCOLINI *et al.* (in press).

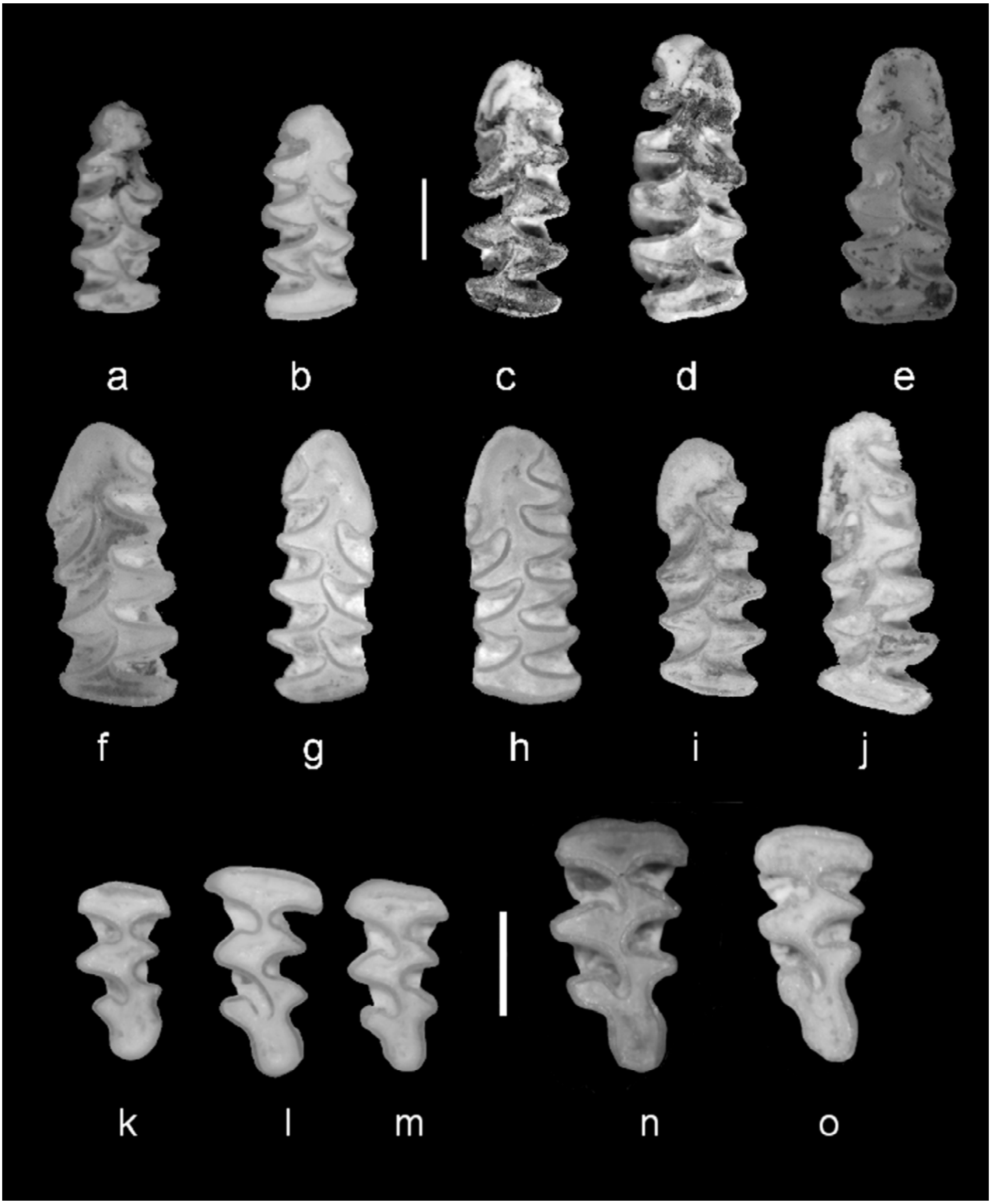


PLATE 1

Tyrrhenicola first lower molars from Monte Tuttavista: **a, b:** quarry X g3, specimens ORX3ty5 and ORX3ty9; **c, d:** quarry XI g3, specimens ORXI3ty39 and ORXI3ty 45; **e, f:** quarry XI canide, specimens ORXIcty82 and ORXIcty 87; **g, h:** quarry XI "dic.2001", specimens ORXI2001ty123 and ORXI2001ty129; **i, j:** quarry VI banco6, specimens ORVI6ty162 and ORVI6ty168.

Tyrrhenicola third upper molars from Monte Tuttavista: **k-m:** quarry X g3, specimens ORX3ty277, ORX3ty278 and ORX3ty279; **n, o:** quarry XI rondone, specimens ORXIroty280 and ORXIroty281. Scale bar represents 1 mm.

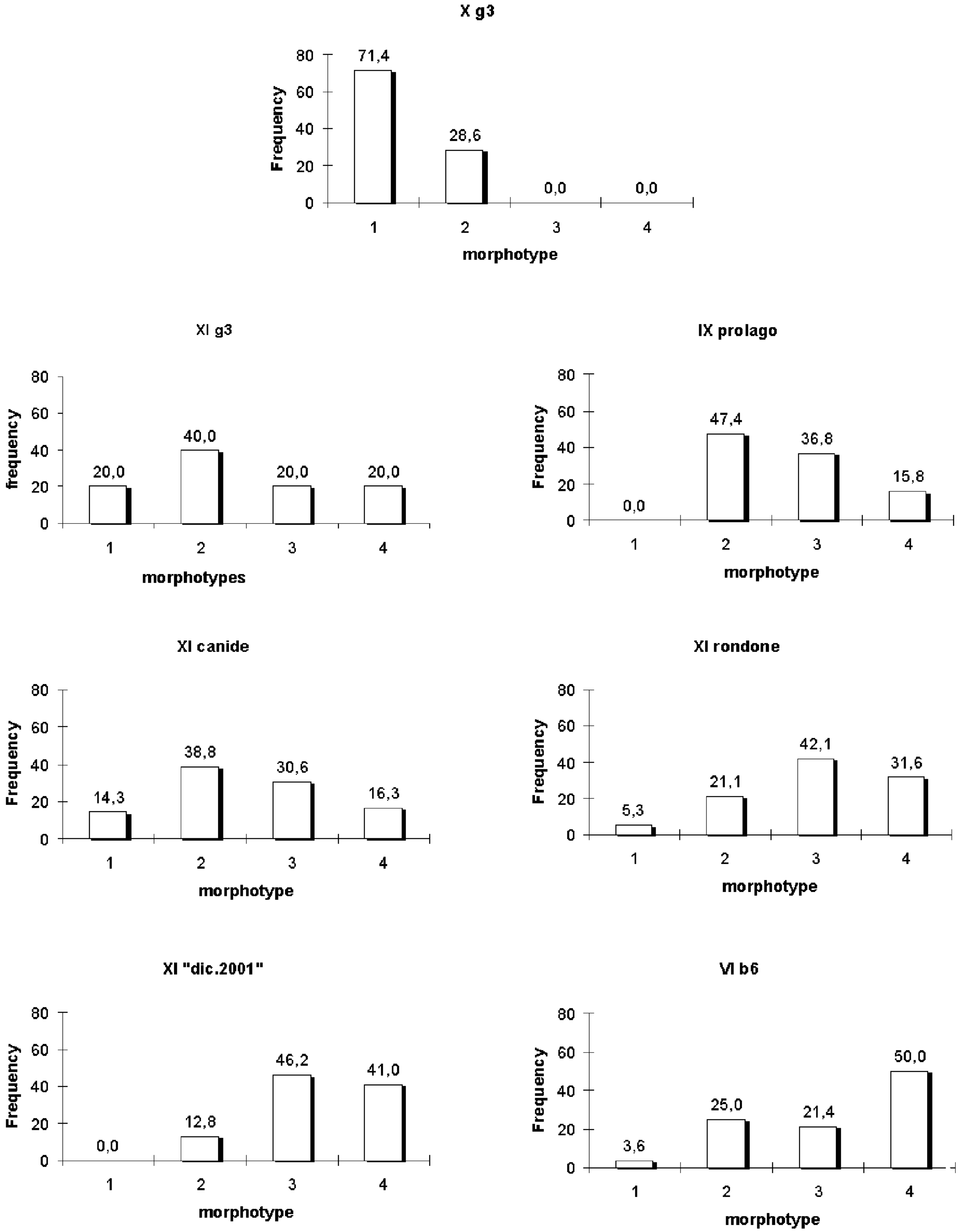


Fig. 3. Histograms of the morphotype frequencies of the Monte Tuttavista populations (expressed as a percentage).

the anterior, according to HEINRICH (1978), who developed this method in order to quantify the trend of enamel differentiation in some species of arvicolids.

DISCUSSION

Several differences showed up between the different populations from Monte Tuttavista quarries (Pl. 1), that allowed a sequencing of the populations in an evolutive order that has been confirmed by the rest of the mammal remains (PALOMBO *et al.*, 2003; ROOK *et al.*, 2003; MARCOLINI *et al.*, in press). The most evolved population is quarry VI banco6 where the majority of the specimens showed a narrow neck between LRA4 and BRA3, a T7 well developed and T6 almost always present even if with different developmental stages. T4 and T5 opposite and confluent and always verging towards the posterior part of the tooth. The other quarries populations showed intermediate features such as a short and rounded Anteroconid in quarry XI g3 specimens, or T6 and T7 retrovergent but with a narrow neck in quarry XI “dic. 2001”, or with a very variable neck —from very narrow to very wide— in quarry XI canide and IX prolago specimens. While specimens from quarry X g3 had a very slightly developed Anteroconid, T6 and T7 only outlined, a neck between LRA4 and BRA3 always large and T4 T5 not confluent.

The analysis of the morphotypes (MARCOLINI *et al.*, in press) allowed a preliminary sequencing of the quarries on the basis of the frequency percentages (Fig. 3; Tab. 1), where quarry X g3 is the only one with a definite predominance of morphotype 1 and no presence of evolved morphotypes 3 or 4.

The same happens when performing a PCA that reduced the initial set of 23 to 12 measurements (Fig. 4; Tab. 2). In this case a good differentiation is visible on a bivariate plot along Axis 1 of First and Second Component explaining 78% of the total vari ance, where two main groups are visible: one composed by quarry X g3 and the other all the other populations. As results from Table 2 the First Principal Component weight is given mainly by V2 and V21, representing two different width of the tooth, one across the tooth axis, the other across T4T5.

ANOVAs and Scheffé test have been therefore performed on these two variables and on AL, the relative elongation of the anteroconid, to determine their significance in the differentiation of the populations and on V6, the total length, to have a final clue whether the size shows a significant variation or not. V2, V21, V6 as well as AL show a significant ANOVA ($p<0.0001$ in all cases; Tab. 3). Scheffé test has been performed (Tab. 4) showing for AL a significant difference between X g3 and all the other populations, moreover between means of quarry VI banco6 / XI “dic.2001” / XI rondone and XI g3 / XI canide / IX prolago. V2, V6 and V21 show a significant difference only between X g3 and all the other populations. This is

TABLE 1
Morphotype frequency percentages of the seven quarries.

Quarries	**Morphotype frequencies (%)**			
	1	**2**	**3**	**4**
X g3	71,4	28,6		
XI g3	20	40	20	20
IX prolago		47,4	36,8	15,8
XI canide	14,3	38,8	30,6	16,3
XI rondone	5,3	21,1	42,1	31,6
XI "dic. 2001"		12,8	46,2	41,0
VI banco6	3,6	25,0	21,4	50,0

TABLE 2
Factor Loadings of Principal Component Analysis.

	Component	
	1	**2**
V1	,724	-,123
V2	,935	-,112
V6	,905	,188
V21	,946	-,153
V24	,840	-,380
V27	,915	-,164
V17	,879	5,19E-02
V19	,781	-,406
V22	,487	-,169
V9	,701	,472
V11	,741	,434
V12	,631	,537

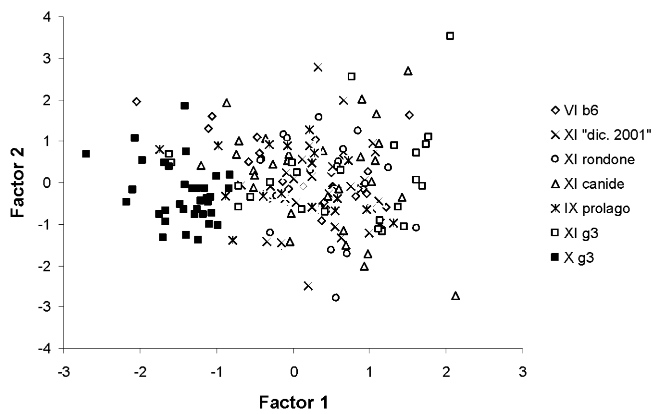


Fig. 4. Principal Component Analysis on 12 occlusal surface measurements.

TABLE 3
ANOVAs results for V2, V6, V21 and AL.

ANOVA

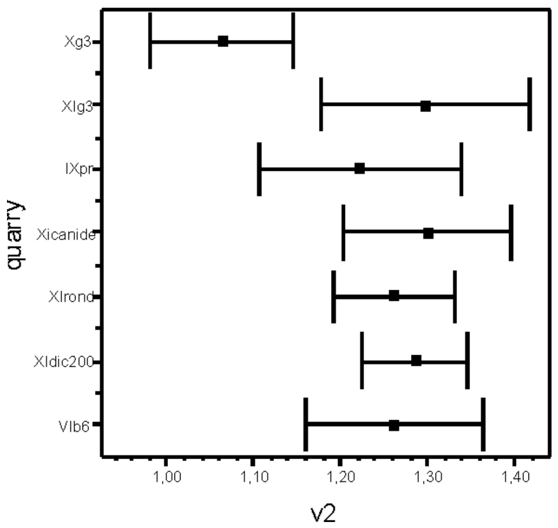
		Sum of Square	df	F	Sig.
V2	Between Groups	1,377	6	25,892	,000
	Within Groups	1,587	179		
	Total	2,964	185		
V6	Between Groups	10,286	6	39,273	,000
	Within Groups	7,814	179		
	Total	18,100	185		
V21	Between Groups	1,355	6	27,596	,000
	Within Groups	1,457	178		
	Total	2,812	184		
AL	Between Groups	1.255,558	6	55,738	,000
	Within Groups	668,276	178		
	Total	1.923,833	184		

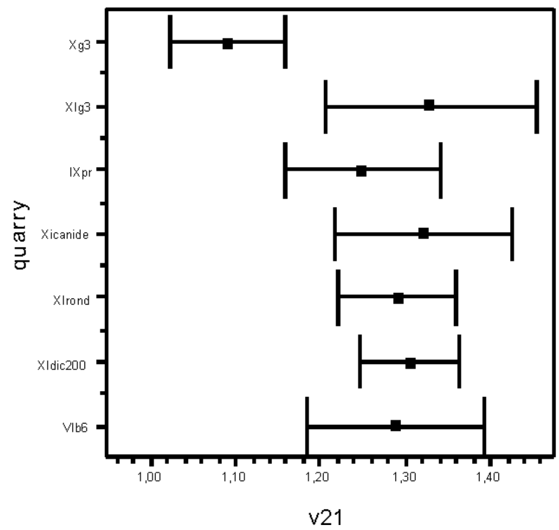
confirmed by the analysis of the homogeneity of subsets of the means (Tab. 5) showing three subsets for AL, meaning that the means of VI banco 6 and XI "dic.2001" or XI rondone do not differ significantly among them, but differ from the means of XI canide, IX prolago and XI g.3 that, on the contrary do not differ significantly among them.

TABLE 4
Scheffè test results for V2, V6, V21 and AL. * represents statistical significance.

Multiple Comparisons
Scheffé

Dependent Variable	(I) quarry	(J) quarry	Mean Difference (I-J)	Std. Error	Sig.
V2	X g3	VI b6	-0,1978*	0,0233	,000
		XI "dic. 2001"	-0,2222*	0,0237	,000
		XI canide	-0,2358*	0,0235	,000
		XI g3	-0,2328*	0,0248	,000
		XI rondone	-0,1977*	0,0267	,000
		IX prolago	-0,1581*	0,0263	,000
V6	X g3	VI b6	-0,5556*	0,0516	,000
		XI "dic. 2001"	-0,5910*	0,0526	,000
		XI canide	-0,5904*	0,0521	,000
		XI g3	-0,6835*	0,0551	,000
		XI rondone	-0,5618*	0,0592	,000
		IX prolago	-0,5084*	0,0583	,000
V21	X g3	VI b6	-0,1975*	0,0224	,000
		XI "dic. 2001"	-0,2142*	0,0228	,000
		XI canide	-0,2309*	0,0226	,000
		XI g3	-0,2383*	0,0238	,000
		XI rondone	-0,1992*	0,0257	,000
		IX prolago	-0,1586*	0,0257	,000
AL	X g3	VI b6	-7,7696*	0,4790	,000
		XI "dic. 2001"	-6,8602*	0,4882	,000
		XI canide	-5,3775*	0,4835	,000
		XI g3	-4,6153*	0,5106	,000
		XI rondone	-5,9662*	0,5494	,000
		IX prolago	-4,2183*	0,5494	,000





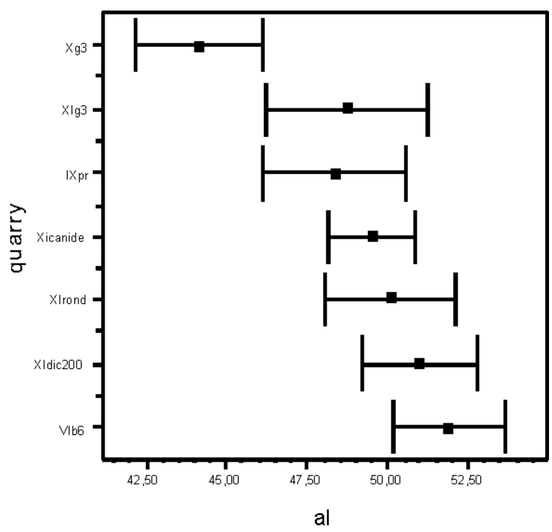


Fig. 5. Bar plots for V2, V21 and AL. Mean ± 1 st. dev.

TABLE 5
Univariate Homogeneous Subsets for AL.

AL

Scheffe

quarry	**N**	**Subset for alpha=.05**		
		1	**2**	**3**
X g3	36	44,1281		
IX prolago	19		48,3463	
XI g3	24		48,7433	
XI canide	29		49,5055	
XI rondone	19		50,0942	50,0942
XI "dic. 2001"	28			50,9882
VI b6	30			51,8977
Sig.		1,000	,122	,098

TABLE 6
Univariate Homogeneous Subsets for V2.

V2

Scheffe

quarry	**N**	**Subset for alpha=.05**	
		1	**2**
X g3	36	1,0639	
IX prolago	20		1,2220
XI rondone	19		1,2616
VI b6	30		1,2617
XI "dic. 2001"	28		1,2861
XI g3	24		1,2967
XI canide	29		1,2997
Sig.		1,000	,202

TABLE 7
Univariate Homogeneous Subsets for V6.

V6

Scheffe

quarry	**N**	**Subset for alpha=.05**	
		1	**2**
X g3	36	2,7261	
IX prolago	20		3,2345
VI b6	30		3,2817
XI rondone	19		3,2879
XI canide	29		3,3166
XI "dic. 2001"	28		3,3171
XI g3	24		3,4096
Sig.		1,000	,185

TABLE 8
Univariate Homogeneous Subsets for V21.

V21

Scheffe

quarry	N	Subset for alpha=.05	
		1	2
X g3	36	1,0908	
IX prolago	19		1,2495
VI b6	30		1,2883
XI rondone	19		1,2900
XI "dic. 2001"	28		1,3050
XI canide	29		1,3217
XI g3	24		1,3292
Sig.		1,000	,142

Population from quarry X g3 indeed forms a separated group for the three variables (Tab. 6 - 8), as it is evidenced by error bar plots, showing the mean ± 1 s.d. (Fig. 5).

Another simple analysis, such as the relationship between width and length of the M_1 and of the M^3, has been performed (Fig. 6, 7), showing a high correlation coefficient (R^2 = 0,746 for M_1 and R^2 = 0,692 for M^3) and a differentiation in two main groups: one composed mainly by quarry X g3 specimens and the second by the other populations.

A final analysis has been the calculation of the SDQ index, according to HEINRICH (1978), on those populations for which a SEM analysis has been possible. It is evident by Fig. 8 how quarry X g3 population has an index clearly greater than 100, ranging from about 101 to 115, while the other populations (VI b6, IX prolago and XI rondone) show an index almost always below 100.

CONCLUSIONS

The morphological qualitative analyses trying to determine quantitative parameters to identify different evolutionary degrees between the populations conducted by MARCOLINI *et al.* (in press) has not proven to be decisive, due to the highly variable characters of the Anteroconid complex. As stated by MEZZABOTTA *et al.* (1996) we are in presence of a clear mosaic evolutionary pattern, visible even in a very restricted area such as that of the Monte Tuttavista.

This is not completely exact for quarry X g3 population that shows indeed a smaller size and a much simpler Anteroconid than the other quarries populations. Such features have been already noticed by CORDY (1997) and SONDAAR (2000) which suggested the possibilities of a new

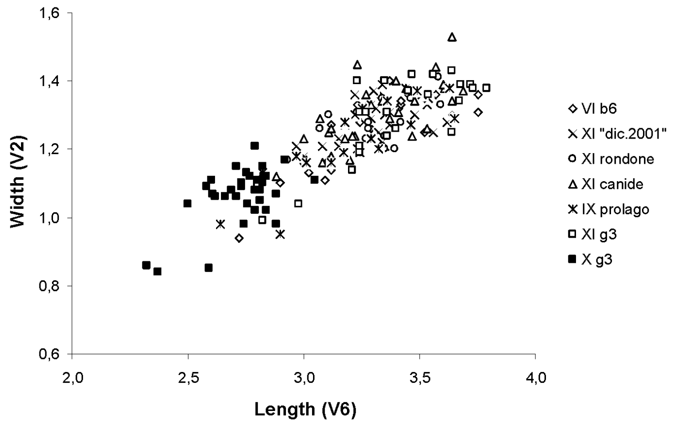


Fig. 6. M_1 length against width plot for all the populations.

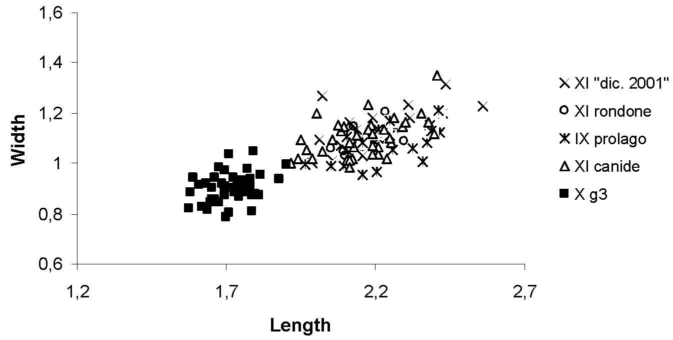


Fig. 7. M^3 length against width plot for all the populations.

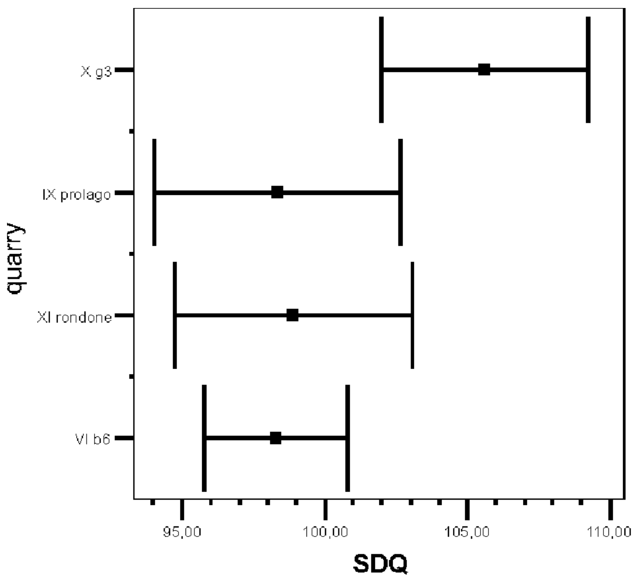


Fig. 8. Bar plots for the SDQ index.

species of *Tyrrhenicola*, possibly related to those archaic remains of Capo Figari and quoted by BRANDY (1978).

The Anteroconid is less developed and comp l i c a t e d , leading to a smaller size, the total absence of morphotypes number 3 or 4 and the predominance of number 1; the SDQ index is always greater than 100, differently from the other populations examined and from other *Microtus* species. All these evidences strongly suggest for the *Tyrrhenicola* of quarry X g3 to be a different species, most likely the ancestor species of *T. henseli*. Comparisons with different *Allophaiomys* species are in course of investigation, in order to give a new contribution on the discussion about the phylogenetic relationships of *Tyrrhenicola* and its derivation.

SYSTEMATICS

Family ARVICOLIDAE GRAY 1821
Genus *MICROTUS* SCHRANK 1798
Subgenus *TYRRHENICOLA* MAJOR 1905
MICROTUS (TYRRHENICOLA)
SONDAARI n. sp.
Figs. 9 and 10 - Plate 1

Derivatio nominis

This species is dedicated to Paul Y. Sondaar, who devoted his life to the study of insular fossil mammals, especially of Sardinian fossil faunas.

Locus typicus

Oroe, Monte Tuttavista, Orosei, Western Sardinia, Italy.

Stratum typicum

Limestone breccia in a reddish clay matrix filling a fissure in quarry X g. 3 “uccelli”, on the southwestern flank of Monte Tuttavista (Orosei, Nuoro, Sardinia), Loc. Oroe.

Age

Early Middle Pleistocene.

Holotype

Right mandible with M_1-M_2 (ORX3ty276) (Fig. 9)

Material

About 1300 molars, 230 M_1, 135 M^3, 20 mandibles with teeth.

Repository

Soprintendenza per i Beni Archeologici per le Province di Sassari e Nuoro, Sede di Nuoro.

Diagnosis

Tyrrhenicola of small size, with very slightly developed Anteroconid in M_1. T6 and T7 only outlined, T9 always lacking. The neck between LRA4 and BRA3 always large and T4T5 not confluent. *Mimomys* – like enamel differentiation. Main measurements in Table 9.

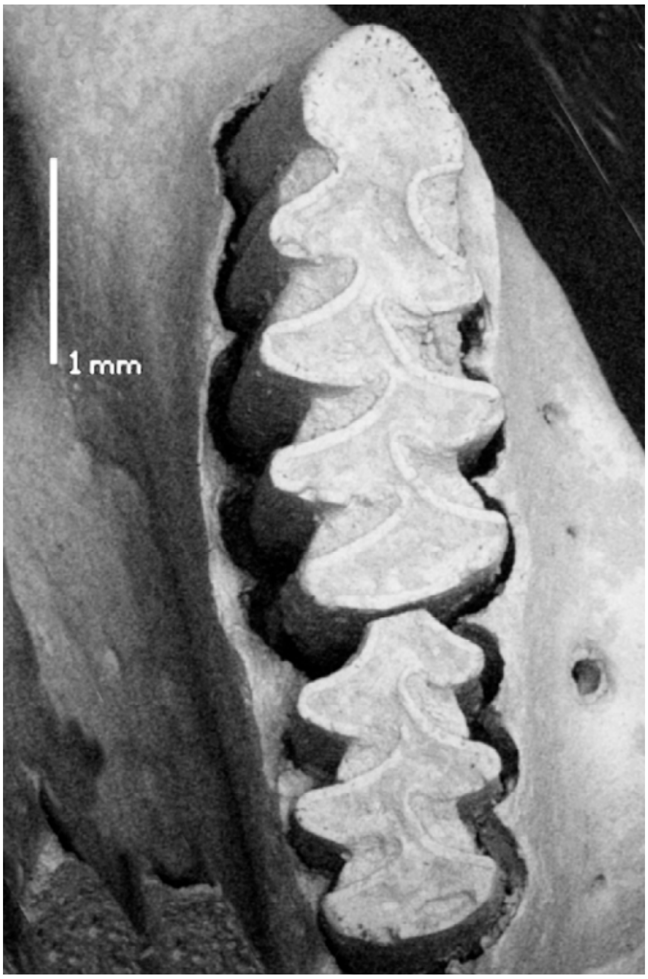


Fig. 9. *Microtus (Tyrrhenicola) sondaari* n. sp. holotype, specimen ORX3ty276. Scale bar represents 1 mm.

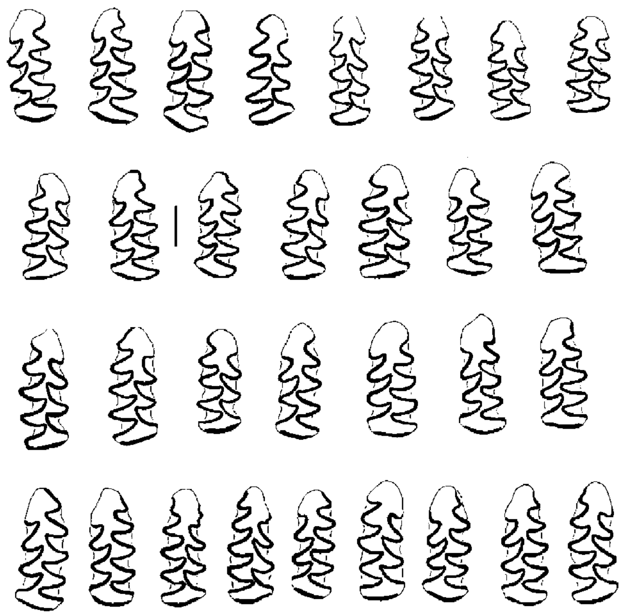


Fig. 10. *Microtus (Tyrrhenicola) sondaari* n. sp. paratypes from quarry X g3. Scale bar represents 1 mm.

TABLE 9
Main measurement in mm. of *Microtus (Tyrrhenicola) sondaari* n. sp. first lower molars.

n=36	average	min	max
L	2,715	2,32	3,05
w	1,067	0,839	1,208
A/L	44,13	39,67	48,40

Description

First lower molars of *M. (T.) sondaari* n.sp. are composed by a posterior loop, three alternating triangles (T1-T3), with T1-T2 slightly confluent, and an anterior loop composed by T4 and T5 rarely confluent and with reentrant angles provergent. T7 when it is present, is pointed and only outlined. Two enamel interruption are present on the sides of the posterior loop; a large enamel interruption run on the anterolabial side of the teeth.

Third upper molars are characterised by an anterior loop, two widely confluent triangles (T2-T3) and a posterior loop with T4 almost not confluent with a well developed T5. Enamel free areas are present laterally to the anterior loop and on the posterior side of the teeth. Length of M^3 between 1,57 and 1,90 mm.

ACKNOWLEDGEMENTS

Since 1995 excavations of Monte Tuttavista faunas have been directed by different superintendents: Dr. F. Lo Schiavo, Dr. F. Manconi and Dr. F. Nicosia, and thanks to the supervision of Dr. M. A. Fadda, responsible of the office of Nuoro.

The authors would like to thank Mr. M. Asole, G. Pittalis, P. Catte, A. Fancello, G. Mercurio, G. Puligheddu and A. Useli, of the Soprintendenza per i Beni Archeologici per le Province di Sassari e Nuoro, Sede di Nuoro, for the precious work preparing the breccias, washing, sieving and selecting the material. Moreover we would like to thank Mrs. Alba Canu and Mrs. Gonaria Demontis responsibles of the SEM-EDS of the Centro di Restauro, Documentazione e Diagnostica of the Soprintendenza per i Beni Archeologici per le prov. di Sassari e Nuoro.

REFERENCES

ABBAZZI, L., ANGELONE, C., ARCA, M., BARISONE, G., BEDETTI, C., DELFINO, M., KOTSAKIS, T., MARCOLINI, F., PALOMBO, M.R., PAVIA, M., PIRAS, P., ROOK, L., TORRE, D., TUVERI, C., VALLI, A. & B. WILKENS (2004). Plio-Pleistocene fossil vertebrates of Monte Tuttavista (Orosei, E. Sardinia, Italy), an overview. *Riv. Ital. Paleont. Strat.*, 110, 603-628.

BRANDY, L.D. (1978). Données nouvelles sur l'évolution du rongeur endémique fossile corso-sarde *Rhagamys* FORSYTH MAJOR (1905) (Mammalia, Rodentia). *Bull. Soc. Géol. Fr.*, sér. 7, 20, 831-835.

BRUNET-LECOMTE, P. & J. CHALINE (1990). Relations phylogénétiques et évolution des campagnols souterrains d'Europe (*Terricola*, Arvicolidae, Rodentia). C.*R. Acad. Sci. Paris*, sér. 2, 311, 737-744.

CHALINE, J. (1972). Les rongeurs du Pléistocène moyen et supérieur de France. *Cahiers de Paléontologie*, CNRS, Paris, 1-410.

CORDY, J.-M. (1997). I karts fossiliferi di Orosei. *I n :* GINESU, S. & J.-M. CORDY (Eds.), *Il Monte Tuttavista Orosei-Galtelli, i riempimenti carsici e la scoperta delle nuove specie del Pleistocene*, 34-45.

HEINRICH W.D. (1978). Zur biometrischen Erfassung eines Evolutionstrends bei *Arvicola* (Rodentia, Mammalia) aus dem Pleistozän Thüringens. *Säugertierk. Inform.*, 2, 3-21.

HINTON, M.A.C. (1926). *Monograph of the Voles and Lemmings (Microtinae) living and extinct*. 1, London, 1-488.

MAJOR, C.I.F. (1905). Rodents from the Pleistocene of the Western Mediterranean region. *G e o l. Magaz.*, dec. 5, 2, 462-467 and 501-506.

MARCOLINI, F., ARCA, M., KOTSAKIS, T. & C. TUVERI (in press). The endemic vole *Tyrrhenicola* (Arvicolidae, Rodentia) from Monte Tuttavista (Sardinia, Italy): new perspectives for phylogeny and biochronology. *Boll. Soc. Hist. Nat. Balears*, 12.

MEULEN, A.J. VAN DER (1973). Middle Pleistocene smaller mammals from the Monte Peglia (Orvieto, Italy) with special reference to the phylogeny of *Microtus* (Arvicolidae, Rodentia). *Quaternaria*, 17, 1-144.

MEZZABOTTA, C., MASINI, F. & D. TORRE (1996). *Microtus (Tyrrhenicola) henseli*, endemic fossil vole from Pleistocene and Holocene loca-lities of Sardinia and Corsica: evolutionary patterns and biochronological meaning. *Boll. Soc. Paleont. Ital.*, 34, 81-104.

MINIERI, M.R., PALOMBO, M.R. & M. SCARANO (1995). *Microtus (Tyrrhenicola) henseli* (Major, 1882) del Pleistocene superiore di Cava Alabastro (Is Oreris; Iglesias; Sardegna sudoccidentale). *Geol. Romana*, 31, 51-60.

PALOMBO, M.R., ABBAZZI, L., ANGELONE, C., ARCA, M., BARISONE, G., BEDETTI, C., DELFINO, M., KOTSAKIS, T., MARCOLINI, F., PAVIA, M., PIRAS, P., ROOK, L., TORRE, D., TUVERI, C., VALLI , A.M.F. & B. WILKENS (2003). Plio-Pleistocene fossil vertebrates of Monte Tuttavista (Orosei, Eastern Sardinia, Italy), new perspectives for insular ecosystem evolution. *Abstr. Intern. Symp: "Insular Vertebrate Evolution: the Paleontological a Approach",* September 16-19 2003, Mallorca, 51-52.

RABEDER, G. (1981). Die Arvicoliden (Rodentia, Mammalia) aus dem Pliozän und dem älteren Pleistozän von Niederösterreich. *Beitr. Paläont. Österr.*, 8, 1-373.

ROOK, L., ABBAZZI, L., ANGELONE, C., ARCA, M., BARISONE, G., BEDETTI, C., DELFINO, M., KOTSAKIS, T., MARCOLINI, F., PALOMBO, M.R., PAVIA, M., PIRAS, P . , TORRE, D., TUVERI, C., VALLI, A.M.F. & B. WILKENS (2003). Osservazioni preliminari sui vertebrati fossili Plio-Pleistocenici del Monte Tuttavista (Orosei, Sardegna). *Sardinia, Corsica et Baleares Antiquae*, 1, 11-30.

SONDAAR P.Y. (2000). Early Human Exploration and Exploitation of islands. *Tropics*, 10, 210-230.