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UPPER PLEISTOCENE MAMMAL ASSEMBLAGE FROM SU CONCALI QUARRY (SAMATZAI, SOUTHERN SARDINIA, ITALY)

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Abstract. A mammal assemblage discovered in a fissure filling located in a quarry near the village of Samatzai (Campidano, southern Sardinia, Italy) is described herein. The following taxa are reported: *Microtus* (*Tyrrhenicola*) *henseli*, *Rhagamys orthodon*, *Prolagus sardus*, *Asoriculus* sp., *Cynotherium sardous* and *Praemegaceros* (*Nesoleipoceros*) *cazioti*. The assemblage ("*Microtus* (*Tyrrhenicola*)" Faunal Complex, Dragonara Faunal Subcomplex) infers a Late Pleistocene age and represents the richest deposit of Quaternary mammals reported in the central Campidano area.

Introduction

Pliocene-Quaternary mammalian assemblages of Sardinia and Corsica have been reported since the 19th century (Cuvier 1812; Studiati in Lamarmora 1857). The rich deposits of numerous Sardinian localities testify insular faunal turnovers characterized by the appearance of new elements from the mainland and the extinction of several taxa (Palombo 1985; Van der Made 1999; Sondaar 2000; Abbazzi et al. 2004; Palombo 2006; Palombo 2009).

Palombo (2009) recognized two main mammalian faunal complexes (FC): the oldest *"Nesogoral"* FC (Late Pliocene - Early Pleistocene), divided into two subcomplexes (FSC) (Mandriola FSC and Capo Figari/Orosei 1 FSC) and the more recent "*Microtus* (*Tyrrhenicola*)" FC (late Early Pleistocene - early Holocene), divided into two FSC: Orosei 2 FSC and Dragonara FSC.

The Pliocene-Quaternary mammal remains of Sardinia primarily originate from karstic fissure fillings and subordinately from aeolian and fluvial-lacustrine deposits. However, the most of the fossiliferous localities are located in correspondence of mainly calcareous outcrops, mostly outside the central areas of Sardinia (Studiati in Lamarmora 1857; Dehaut 1911; Comaschi Caria 1968; Malatesta 1970; Abbazzi et al. 2004). Therefore, the description of new fossiliferous sites from poorly investigated areas of Sardinia represents an additional source of data.

In the 2004, during the quarrying activity of the Company "Italcementi S.p.A.", several deer bone fragments were discovered within a fissure filling located in the Su Concali Quarry, near the village of Samatzai (Cagliari, Sardinia). In the same year an excavation campaign was conducted by a team of the University of Cagliari in order to recover the palaeontological material. The aim of this paper is to provide a preliminary description of the new mammal assemblage of Su Concali Quarry and to propose a biochronological assignment.

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Geological setting

The studied fissure filling was located in the limestone quarry named Su Concali, about 2 km NW from the village of Samatzai (Campidano, southern Sardinia, Fig. 1). Currently, the fossiliferous site is no longer present due to the ongoing quarrying activity.

The quarry was opened in the marine succession of the Villagreca Limestone (upper Oligocene - lower Burdigalian) (Pecorini & Pomesano Cherchi 1969) and the Quaternary fossiliferous deposit was represented by multiple phases of filling due to water flows (Fig. 2).

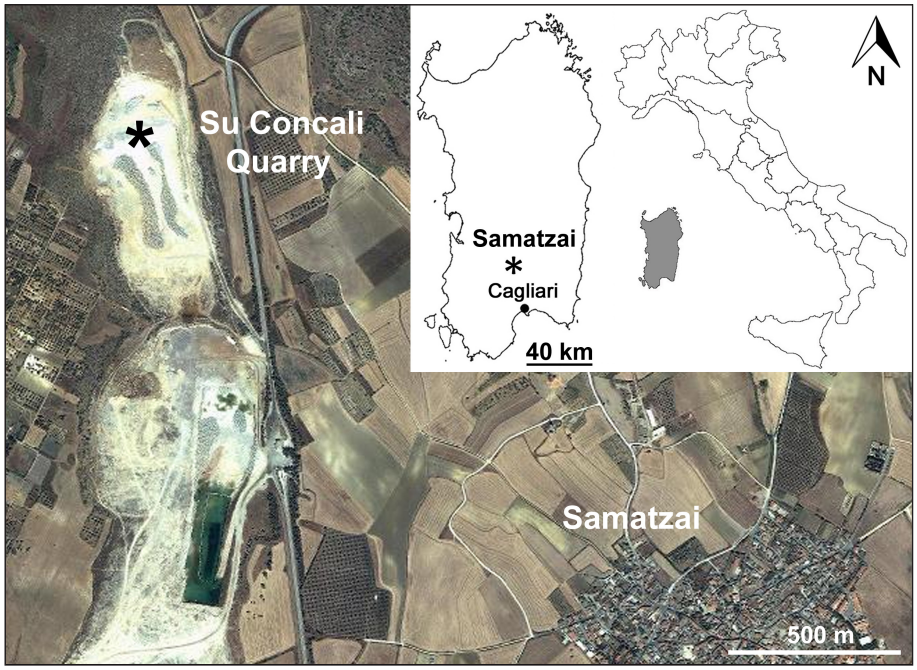

Fig. 1 - Location map of the Su Concali Quarry.

Three layers characterized by different types of sediments were distinguishable in the fissure filling. From top to bottom they are:

- Soil (Fig. 2B-c).

- Uncemented red clay (Fig. 2B-d), localized between the soil and the underlying cemented red claystone. Poorly preserved vertebrate remains were found in this layer (1.9 m).

- Poorly cemented red clay (Fig. 2B-e) with a heterogeneous structure and a huge number of bone fragments (2 m).

- Highly cemented bed with siliciclastic sediments, heterometric calcareous pebbles and indications of probable landslides (Fig. 2B-f). This bed was characterized by the presence of stalactites and other carbonate concretions that covered the walls of the cavity, the pebbles and several deer bones (1.4 m).

The deer bones are generally highly fragmented and poorly preserved. Indeed, it was possible to identify only a limited number of elements, mainly related to teeth, jaws and limb bones. The state of preservation of the bones probably indicates a long transportation by water flows.

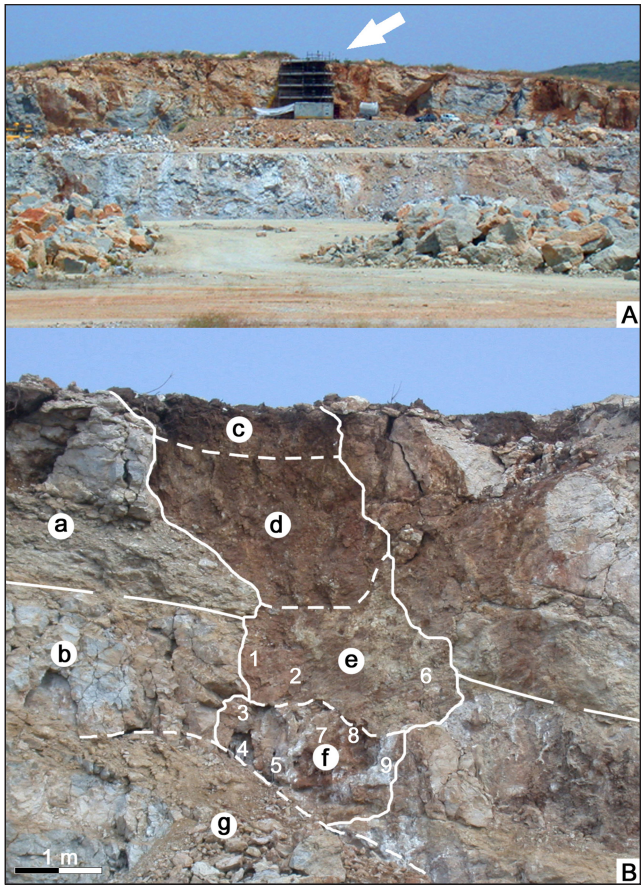

Fig. 2 - A) Overview of the Su Concali Quarry during the palaeontological excavation campaign (July, 2004); the white arrow indicates the position of the fossiliferous site. B) The fissure filling before the excavation and location of the sampling points: a, marly limestones (upper Oligocene - lower Burdigalian); b, ostreid-bearing limestones (upper Oligocene - lower Burdigalian); c, soil; d, uncemented red clay; e, poorly cemented red clay; f, highly cemented level with carbonate concretions; g, debris; 1, SX3.80-4.00m; 2, SX4.00-4.10m; 3, SX4.30-4.50m; 4, SX4.80m"fault"; 5, SX4.50-5.00m; 6, DX4.00-4.10m; 7, DX4.50m"mandible"; 8, DX4.50m; 9, DX4.80-5.00m.

Materials and methods

We used an air engraving pen (3400BPM) to prepare the macromammal bones. Afterwards, the most fragile fossils were consolidated using Paraloid B-72. Subsequently, we used a digital caliper (Rupac 0-150mm/0.01 ABS) to measure the macromammal remains. We collected sediments from different levels of the fissure filling (Fig. 2B) in order to recover the small fossil remains: SX3.80-4.00m, SX4.00-4.10m and DX4.00-4-10m from the poorly cemented red clay, and SX4.30-4.50m, SX4.80m"fault", SX4.50-5.00m, DX4.50m "mandible", DX4.50m and DX4.80-5.00m from the highly cemented level. The sampled sediments were sifted using wet sieves (2.5 - 0.5 mm) and afterward the dried residues were inspected using a Leica MS5 stereomicroscope to recover micromammal remains. Measurements and photographs of the studied micromammal fossils were performed using a Nikon D5000 mounted on a Leica MS5 stereomicroscope. Comparison was made using samples stored in the Museo Sardo di Geologia e Paleontologia D. Lovisato of Cagliari and literature data (Malatesta 1970; Caloi & Malatesta 1974; Mezzabotta et al. 1995; Minieri et al. 1995; Abbazzi et al. 2005; Van der Made & Palombo 2006; Madurell-Malapeira et al. 2015).

Forty-four m1 of *Microtus* (*Tyrrhenicola*) *henseli* (Major, 1905) have been studied. Comparison was made with samples of *M.* (*Tyrrhenicola*) spp. from various Sardinian localities (data from Mezzabotta et al. 1995; Minieri et al. 1995; Marcolini et al. 2005, 2006; Boldrini 2008; Boldrini et al. 2010; Zoboli & Pillola 2016). Measurements and morphological indices of m1 of *M.* (*Tyrrhenicola*) *henseli* were taken according to Van der Meulen (1973) and Marcolini et al. (2006) with further modifications as proposed by Boldrini (2008). The nomenclature and the measurements used in this paper follow Michaux (1971) for the murid teeth, López Martínez (1989) and Angelone (2007) for the ochotonid teeth and Reumer (1984) for the soricid teeth. Macromammal remains were measured according to Von den Driesch (1976) and Van der Made (2012). All measurements are given in mm. The studied material is stored at the Museo Sardo di Geologia e Paleontologia Domenico Lovisato of the University of Cagliari.

Abbreviations

Institutions: MDLCA, Museo Sardo di Geologia e Paleontologia Domenico Lovisato, University of Cagliari. Terminology, measurements and morphological indices of the occlusal surface of the first lower molar of *Microtus* (*Tyrrhenicola*) *henseli*: ACC, antero-conid complex; TTC, trigonid-talonid complex; AC, anterior cap; T, triangle; BSA, buccal salient angle; BRA, buccal reentrant angle; LSA, lingual salient angle; LRA, lingual reentrant angle; PL, posterior loop; V1, total length; V2, total width; V3, Length of posterior part of BRA2; V4, width of the neck; A/L, length of ACC against total length (V1-V3)/V1 *100; LAC, V4/V1; W/L, width against total length; min, minimum; max, maximum; n, number of measured elements. Measurements of firsts cheek teeth of *Rhagamys orthodon*: L, total length; W, total width; n, number of measured elements. Measurements of Soricidae teeth: PE, length of the posterior emargination; LL, lingual length; BL, buccal length; AW, anterior width; PW, posterior width; TRW, trigonid width, TAW, talonid width; L, length. Measurements of the p3 of *Prolagus sardus*: L max, maximum length; L min, minimum length; L mean, mean length; W max, maximum width; W min, minimum width; W mean, mean width. Measurements of teeth and mandibles of *Praemegaceros* (*Nesoleipoceros*) *cazioti*: DAP: antero-posterior diameter (or tooth length), DAPb: DAP measured at the base of a tooth, DTa: transverse diameter of the anterior lobe, DTp: transverse diameter of the posterior lobe, DTpp: transverse diameter of the third lobe in a m3, Dbu, depth of the mandible measured below each cheek tooth from p2 to m3, depth is measured at the lingual side; d, right elements; s, left elements.

Systematic palaeontology

Order **Rodentia** Bowdich, 1821
Family Cricetidae Fischer, 1817
Genus *Microtus* Schrank, 1798
Subgenus *Tyrrhenicola* Major, 1905

Microtus* (*Tyrrhenicola*) *henseli (Major, 1905)

Fig. 3C

Material: MDLCA23622: one isolated m1, two incomplete hemimandibles and one incomplete maxillae from SX3.80-4.00m; MDLCA23623: two m1 and one incomplete hemimandible from SX4.00-4.10m; MDLCA23624: nine m1 from DX4.00-4-10m; MDLCA23625: one isolated m1 and one incomplete hemimandible from SX4.30-4.50m; MDLCA23626: two m1 from SX4.80m "fault"; MDLCA23627: eleven isolated m1 and two right incomplete hemimandibles from SX4.50-5.00m; MDLCA23628: one isolated m1 and one incomplete hemimandible from DX4.50m"mandible"; MDLCA23629: two isolated m1 and three incomplete hemimandibles from DX4.50m; MDLCA23630: five m1 and one incomplete hemimandible from DX4.80-5.00m.

Remarks. *Microtus* (*Tyrrhenicola*) is the most abundant micromammal of the fissure filling. The analyzed m1 are characterized by long and asymmetrical anterior cap, developed sixth triangle and narrow neck (Fig. 3C).

The first lower molar of *M.* (*Thyrrhenicola*) spp. shows a wide morphologic variability. Mezzabotta et al. (1995) recognize four morphotypes classes of m1. The most primitive class includes small m1 with a simple and short anterior cap, large neck and poorly developed or absent T6, whereas the most derived class includes large m1 with long asymmetrical anterior cap, developed T6, narrow neck and always present T7. The intermediate classes include m1 with transitional features (Mezzabotta et al. 1995).

The analysis of m1 of *M.* (*Tyrrhenicola*) from Su Concali (Figs 4-5, Tabs 1-2) attest the presence of advanced morphotypes in all levels of the fissure filling. The sample appears to be comparable with the most advanced *M.* (*Thyrrhenicola*) *henseli* populations of Sardinia and differs widely from the primitive morphotypes of *M.* (*Tyrrhenicola*) *henseli* and *M.* (*Tyrrhenicola*) *sondaari* Marcolini, Tuveri, Arca & Kotsakis, 2006 (Fig. 6).

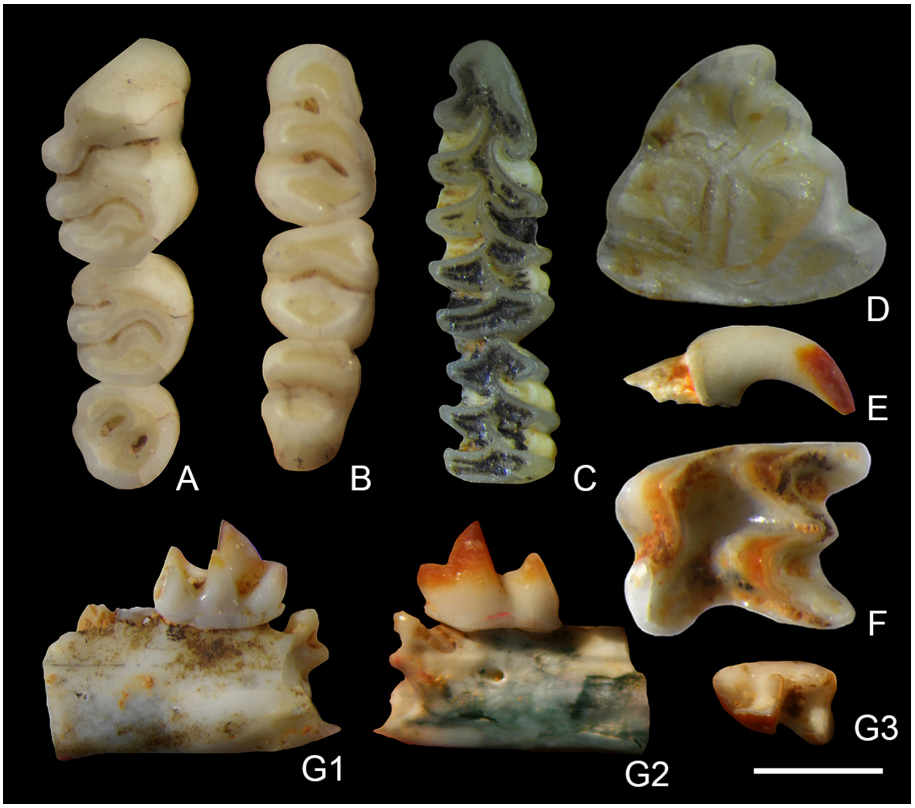

Fig. 3 - Micromammals of Su Concali Quarry. A, B) *Rhagamys orthodon* from SX4.30-4.50m (MDLCA23621), A - M1-M3 in occlusal view, B - m1-m3 in occlusal view. C) *Microtus* (*Tyrrhenicola*) *henseli* from SX4.50-5.00m (MDLCA23627), m1-m2 in occlusal view. D) *Prolagus sardus* from SX4.00-4.10m (MDLCA23631), p3 in occlusal view. E, F, G) *Asoriculus* sp. from SX4.80m"fault" (MDLCA23634), E - upper right incisor in labial view, F - left M2 in occlusal view, G - incomplete left mandible with incomplete p4 and m1 in lingual 1) and buccal 2) views, and m1 in occlusal view 3). Scale bar: figs A-D = 1 mm; figs E, G = 2 mm; fig. F = 1.5 mm.

	SX3.80-4.00m (n=3)			SX4.00-4.10m (n =3)			DX4.00-4.10m (n=9)		
	min	max	average	min	max	average	min	max	average
V1	2.92	3.38	3.17	3.23	3.39	3.33	2.92	3.53	3.26
V2	1.23	1.30	1.26	1.30	1.39	1.35	1.26	1.39	1.32
V3	1.38	1.69	1.53	1.55	1.69	1.61	1.46	1.70	1.58
V4	0.07	0.15	0.10	0.14	0.23	0.18	0.11	0.26	0.17
ACC	1.54	1.85	1.64	1.62	1.84	1.71	1.39	1.92	1.67
A/L	47.6	54.7	51.6	50	54.20	52.10	47.6	52.6	51.1
LAC	0.02	0.04	0.03	0.04	0.06	0.05	0.03	0.08	0.05
W/L	0.38	0.42	0.40	0.38	0.43	0.40	0.37	0.44	0.40
	SX4.30-4.50m (n=2)			SX4.80m"fault" (n=2)			SX4.50-5.00m (n=13)		
	min	max	average	min	max	average	min	max	average
V1	3.23	3.38	3.30	3.30	3.39	3.34	2.92	3.54	3.33
V2	1.23	1.30	1.26	1.37	1.38	1.37	1.23	1.53	1.36
V3	1.53	1.69	1.61	1.54	1.69	1.61	1.38	1.76	1.59
V4	0.19	0.26	0.22	0.19	0.38	0.28	0.11	0.30	0.18
ACC	1.69	1.70	1.69	1.70	1.76	1.73	1.54	1.91	1.74
A/L	50	52.6	51.3	50.1	53.3	51.7	46.9	56.1	52.2
LAC	0.05	0.07	0.06	0.05	0.10	0.07	0.03	0.08	0.05
W/L	0.38	0.38	0.38	0.40	0.41	0.40	0.38	0.46	0.40
	DX4.50m"mandible" (n=2)			DX4.50m (n=4)			DX4.80-5.00m (n=6)		
	min	max	average	min	max	average	min	max	average
V1	3.23	3.38	3.30	3.00	3.69	3.32	2.92	3.38	3.18
V2	1.23	1.46	1.36	1.08	1.53	1.29	1.23	1.32	1.31
V3	1.60	1.61	1.60	1.38	1.69	1.55	1.24	1.69	1.52
V4	0.19	0.23	0.21	0.07	0.30	0.21	0.15	0.26	0.20
ACC	1.62	1.78	1.70	1.54	2.00	1.77	1.54	2.00	1.66
A/L	50.1	52.6	51.3	50.1	54.3	53.1	48.6	61.7	52.1
LAC	0.05	0.07	0.06	0.02	0.10	0.06	0.05	0.09	0.06
W/L	0.38	0.43	0.40	0.36	0.42	0.38	0.38	0.47	0.41

Tab. 1 - Measurements (in mm), descriptive statistics of variables and morphological indices of the first lower molar of *Microtus* (*Tyrrhenicola*) *henseli* from various levels of Su Concali Quarry.

	Su Concali Quarry (n = 44)							
	V1	V2	V3	V4	ACC	A/L	LAC	W/L
min	2.92	1.08	1.24	0.07	1.39	46.9	0.02	0.36
max	3.54	1.53	1.76	0.38	2.00	61.7	0.10	0.47
average	3.28	1.33	1.58	0.19	1.67	51.9	0.05	0.40

Tab. 2 - Measurements (in mm), descriptive statistics of variables and morphological indices of the m1 of *Microtus* (*Tyrrhenicola*) *henseli* of Su Concali Quarry.

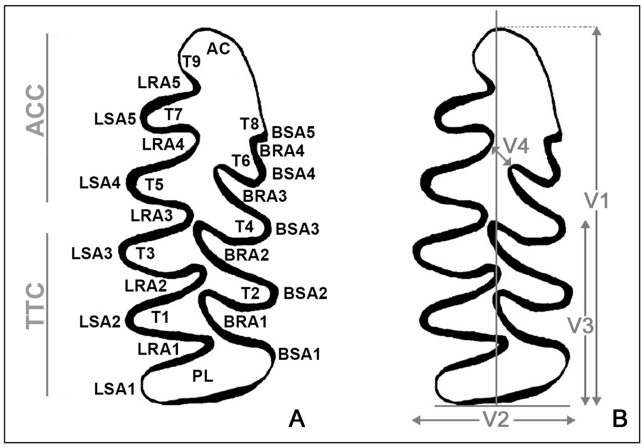

Fig. 4 - A) Terminology of the first lower molar occlusal surface of cricetids (modified from Van der Meulen 1973). B) Sketch of measurements of the m1 of *Microtus* (*Thyrrhenicola*) *henseli*.

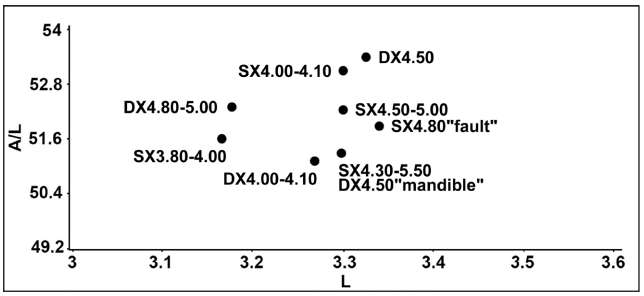

Fig. 5 - L against A/L of m1 of *Microtus* (*Tyrrhenicola*) *henseli* from various levels of Su Concali Quarry.

Family Muridae Illiger, 1811
Genus *Rhagamys* Major, 1905

Rhagamys orthodon (Hensel, 1856)

Fig. 3A, B

Material: MDLCA23618: four isolated M1, five isolated M2, two isolated M3, three isolated m1 and one isolated m2 from DX4.80-5.00m; MDLCA23619: three isolated M1, two isolated M2, two isolated m1 and one incomplete left hemimandible with incisive and m1 from DX4.50m; MDLCA23620: one isolated M2, five isolated m1, one isolated m2, two isolated m3, one fragmentary left hemimandible with incisive and m1, one incomplete hemimandible with m2-m3 and one fragmentary right hemimandible with m1-m2 from SX4.80 "fault"; MDLCA23621: four isolated M1, two isolated M2, one isolated m1, two isolated m2, one isolated m3, two incomplete right hemimandibles and one incomplete left maxilla from SX4.30-4.50.

		DX4.80-5.00m					SX4.80m"fault"		
		min	max	average			min	max	average
M1	L	2.62	2.71	2.66	M1	L			
n=3	W	1.64	1.72	1.66		W			
m1	L	2.52	2.82	2.62	m1	L	2.29	2.72	2.54
n=3	W	1.54	1.65	1.57	n=7	W	1.40	1.63	1.55
		DX4.50m					SX4.30-4.50m		
		min	max	average			min	max	average
M1	L	2.52	2.72	2.64	M1	L	2.25	2.75	2.57
n=3	W	1.52	1.74	1.63	n=5	W	1.52	1.72	1.62
m1	L	2.21	2.53	2.42	m1	L	2.22	2.60	2.41
n=3	W	1.54	1.62	1.56	n=2	W	1.41	1.53	1.47

Tab. 3 - Measurements (in mm) of the first cheek teeth of *Rhagamys orthodon* of Su Concali Quarry.

Remarks. The cheek teeth of the murid of Su Concali Quarry are characterized by marked hypsodonty, the unworn M1 show the first and the second tubercles not clearly separated.

An endemic murid lineage is known in the Plio-Quaternary of the Corso-Sardinian massif. *Rhagapodemus azzarolii* Angelone & Kotsakis, 2001, the oldest taxon of this lineage, is reported in the Capo Mannu D1 local fauna (Madriola) (Angelone & Kotsakis 2001; Abbazzi et al. 2008; Piras et al. 2012). *Rhagapodemus minor* (Brandy, 1978) is the second taxon of the lineage and is reported in a few Early Pleistocene localities of Sardinia and Corsica (Brandy 1978; Abbazzi et al. 2004; Piras et al. 2012). *Rhagamys orthodon* (Hensel, 1856) represents the most recent and common species, reported in several localities from the Middle Pleistocene to the Early Holocene (Comaschi Caria 1968; Vigne 1992). The transition between *R. minor* and *R. orthodon* is marked by an increase in dimension and hypsodonty (Brandy 1978; Piras et al. 2012). Based on their size, the samples from Su Concali Quarry are clearly referable to *R. orthodon* (Fig. 7, Tab. 3).

Order **Lagomorpha** Brandt, 1855
Family Ochotonidae Thomas, 1897
Genus *Prolagus* Pomel, 1853

Prolagus sardus (Wagner, 1829)

Fig. 3D

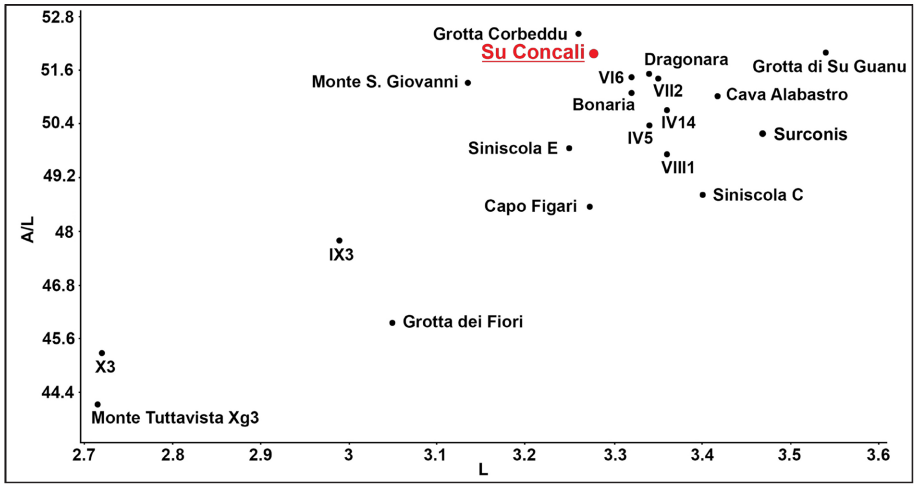

Fig. 6 - L against A/L of m1 of *Microtus* (*Tyrrhenicola*) spp. from various localities of Sardinia. Monte Tuttavista Xg3 is the type locality of *M.* (*Tyrrhenicola*) *sondaari* (data from Mezzabotta et al. 1995; Minieri et al. 1995; Marcolini et al. 2005, 2006; Boldrini 2008 and Zoboli & Pillola 2016).

Material: MDLCA23631: three incomplete hemimandibles, two incomplete lower incisors and five incomplete cheek teeth from SX4.00-4.10m; MDLCA23632: one incomplete hemimandible, five cheek teeth fragments and one incomplete right femur from SX4.30-4.50; MDLCA23633: two incomplete hemimandibles, one incomplete maxilla, two incomplete cheek teeth and one incomplete upper incisor from DX4.00-4.10m.

Remarks. *Prolagus* is represented by isolated teeth, incomplete hemimandibles and poorly preserved postcranial elements. Only three isolated p3 (MDLCA23631) with a complete occlusal surface have been measured (L max = 2.27, L min = 2.21, L mean = 2.23, W max = 2.51, W min = 2.39, W mean = 2.45). The collected teeth show a posteriorly indented and lingually elongated anteroconid (Fig. 3D).

Prolagus sardus is probably the most common taxon in the Quaternary insular mammal assemblages of Sardinia and Corsica. This lagomorph is typical of the Dragonara FCS and its fossils are usually very abundant in caves, fissure fillings and anthropogenic deposits of the end of the Middle Pleistocene - Early Holocene (until the Iron Age) (Comaschi Caria 1968; Vigne 1992; Wilkens 2000).

Unexpectedly, *Prolagus* remains are scarce and poorly preserved in the fissure filling. However, the features of the ochotonid of Su Concali suggest a comparison with the advanced morphotypes recognized by Angelone et al. (2008).

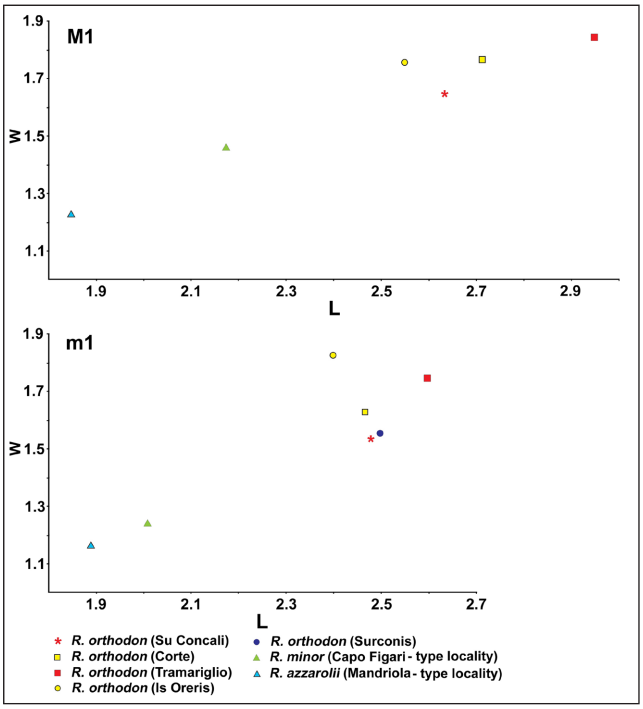

Fig. 7 - L against W of the first cheek teeth of *Rhagapodemus azzarolii*, *Rhagapodemus minor* and *Rhagamys orthodon* from various localities of Sardinia and Corsica (data from Brandy 1978; Gliozzi et al. 1984; Angelone & Kotsakis 2001 and Zoboli & Pillola 2016).

Order **Eulipotyphla** Waddell, Okada & Hasegawa, 1999
Family Soricidae Fischer, 1814
Genus *Asoriculus* Kretzoi, 1959

Asoriculus sp.
Fig. 3E, F, G

Material: MDLCA23634: two upper right incisors, one left M2, one incomplete left hemimandible with incomplete p4 and complete m1 and one isolated incomplete m1 from SX4.80m"fault;" MDLCA23635: nine fragments of cheek teeth from SX4.80m"fault".

Remarks. The upper incisors are bifid with stout and not very elongated first cousp. The M2 shows a well developed metacone crest. In the posterior

wall of the tooth, a wide groove is present between the metacone and hypocone. The m1 shows a straight lingual wall, aligned paraconid and metaconid, developed hypoconid and entoconid and a lingually developed cingulum. The following linear measurements have been taken from two teeth: M2: AW = 3.62, PW = 3.22, BL = 2.65, PE = 2.31, LL = 2.74; m1: L = 2.14, TRW = 1.17, TAW = 1.33.

Two formally described species and two undetermined species attributed to the genus *Asoriculus* are reported in Sardinia (Van der Made 1999; Abbazzi et al. 2004; Furió & Angelone 2010). The oldest remains of this genus are reported in the Late Pliocene of Capo Mannu D1 (often cited as Mandriola, central-western Sardinia) and were attributed to the European mainland form *Asoriculus gibberodon* (Peteneyi, 1864) (Furió & Angelone 2010). Several endemic forms probably evolved from *A. gibberodon* are recognized in the Quaternary of the Corso-Sardinian massif: *Asoriculus corsicanus* (Bate, 1945), *Asoriculus similis* (Hensel, 1855), *"Nesiotites"* (=*Asoriculus*) sp. 1 (bigger and recent form from Mt. Tuttavista) and *"Nesiotites"* (=*Asoriculus*) sp. 2 (smaller and oldest form from Mt. Tuttavista). *Asoriculus similis* is the most common shrew in the Sardinian fossil record. This taxon, initially classified as *Sorex similis* by Hensel (1855), is a relatively big size shrew signaled in the Late Pleistocene - Early Holocene. Bate (1945) included all the Corso-Sardinian and the Balearic shrews in the new genus *Nesiotites*; however, in recent times only the Balearic forms are generally attributed to this genus (Van der Made 1999; Rofes et al. 2012) while the Corso-Sardinian fossils are usually referred to *"Nesiotites"* (Abbazzi et al. 2004; Furió & Angelone 2010) or *Asoriculus* (Van der Made 1999; Rofes et al. 2012).

Pending a revision of the Corso-Sardinian shrews, the Soricidae of Su Concali Quarry is referred to *Asoriculus* sp.

Order **Carnivora** Bowdich, 1821
Family Canidae Fischer, 1817
Genus *Cynotherium* Studiati, 1857

Cynotherium sardous Studiati, 1857
Fig. 8

Material: MDLCA23614: one incomplete left M1; MDLCA23615: one right m2; MDLCA23616: one incomplete right m2; MDLCA23617: one incomplete left I3. All material from DX4.00m.

Remarks. Four isolated and incomplete teeth are the only Canidae remains found in the deposit. A right m2 (MDLCA23615, Fig. 8A) is the only tooth that presents a complete crown. This bean-shaped and bicuspidate tooth is somewhat

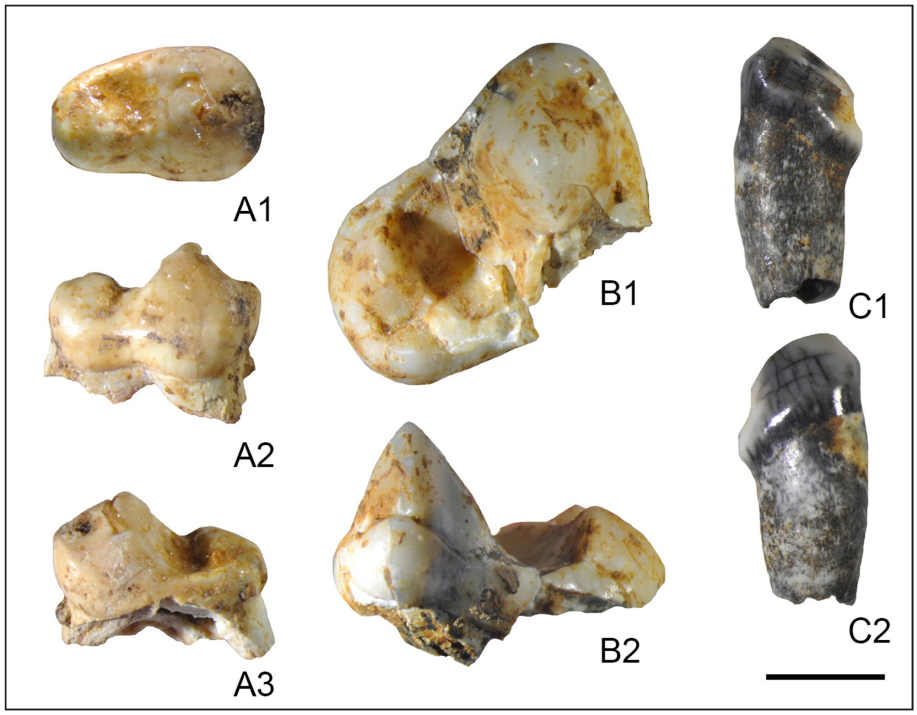

Fig. 8 - *Cynotherium sardous* from Su Concali Quarry. A) MDLCA23615, isolated right m2 in occlusal 1), buccal 2) and lingual 3) views. B) MDLCA23614, incomplete left M1 in occlusal 1) and anterior 2) views. C) MDLCA23617, incomplete left I3 in lingual 1) and buccal 2) views. Scale bar = 1 cm.

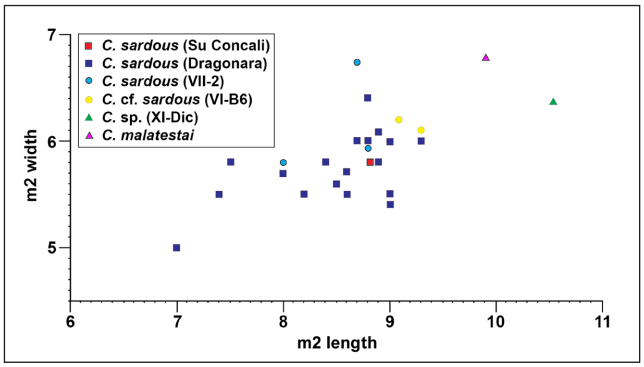

Fig. 9 - m2 proportions in *Cynotherium sardous* from Su Concali Quarry compared with C. *sardous*, *C.* cf. *sardous*, *C.* sp. and *C. malatestai* from various localities of Sardinia. VII-2, VI-B6 and XI-Dic are fissure fillings of Mt. Tuttavista. Measurements were taken from the literature (Malatesta 1970 for Dragonara Cave, Abbazzi et al. 2005 for Mt. Tuttavista and Madurell-Malapeira et al. 2015 for *C. malatestai*).

worn but still shows the peculiar features of the genus *Cynotherium* (Studiati in Lamarmora 1857; Malatesta 1970). This m2 is 8.92 in length and 5.80 in width. The other collected teeth show incomplete crowns and broken roots. The crown of the only recovered M1 is incompletely preserved (MDLCA23614, Fig. 8B). A one-rooted tooth with broken crown is probably referable to an upper incisive (MDLCA23617, Fig. 8C).

Cynotherium represents one of the most peculiar elements in the mammalian assemblages of Sardinia and Corsica during the Quaternary. This insular genus was established by Studiati (1857) based on the material collected by Lamarmora in the Pleistocene breccias of Bonaria (Cagliari). *Cynotherium* is present in the Corso-Sardinian massif with two species: *C. sardous* Studiati, 1857 (Middle - Late Pleistocene) and its ancestor *C. malatestai* Madurell-Malapeira et al., 2015 (?late Early Pleistocene and/or early Middle Pleistocene). Furthermore, Abbazzi et al. (2005) reported Canidae indet., *Cynotherium* sp. and *Cynotherium* cf. *sardous* from several fissure fillings of Mt. Tuttavista.

In agreement with the detailed description of this taxon provided by Malatesta (1970), the canid from Su Concali Quarry shows several of the main features that characterize the endemic genus *Cynotherium*. The dentition is comparable in size with the most recent *C. sardous* and differs from the oldest samples of Mt. Tuttavista and *C. malatestai* (Fig. 9). Therefore, the canid remains from Samatzai are assigned to *C. sardous*.

Order **Artiodactyla** Owen, 1848
Family Cervidae Goldfuss, 1820
Genus *Praemegaceros* Portis, 1920
Subgenus *Nesoleipoceros* Radulesco & Samson, 1967

Praemegaceros* (*Nesoleipoceros*) *cazioti
(Depéret, 1897)

Fig. 10

Material: MDLCA23583: incomplete left hemimandible with p2-m3; MDLCA23584: incomplete right hemimandible with p3-m2; MDLCA23585: incomplete right hemimandible with p4-m2; MDLCA23586: incomplete left hemimandible with m2-m3; MDLCA23587: incomplete right hemimandible with p2-p3 roots; MDLCA23588: one incomplete right i1; MDLCA23589: one incomplete left i2; MDLCA23590: one isolated right p3; MDLCA23591: one isolated left p2; MDLCA23592: one incomplete right m2; MDLCA23593: one incomplete right m2; MDLCA23594a-b: two incomplete right M3; MDLCA23595: one right M2 fragment; MDLCA23596, MDLCA23597, MDLCA23598, MDLCA23600: four incomplete right humeri; MDLCA23599, MDLCA23601: two incomplete left humeri; MDLCA23602, MDLCA23603: two incomplete left radii; MDLCA23604: one incomplete right tibia; MDLCA23605, MDLCA23606: two metapodial distal fragments; MDLCA23607: one incomplete left astragalus; MDLCA23608: one left unciform; MDLCA23609: one left capitate; MDLCA23610, MDLCA23611: two second phalanges; MDLCA23612, MDLCA23613: two third phalanges.

Remarks. Most part of the megacerine deer remains was found in the lower and highly cemented level of the fissure filling. The fossils are rela-

Coll. number			DAP	DAPb	DTa	DTp	DTpp	Dbu
MDLCA 23583	s	p2	12.1	10.6				
		p3	17.6	15.9				28
		p4	16.5	16				29.3
		m1	24	20.3				33
		m2	24.6	21.5				
		m3	27.6	27				
MDLCA 23584	d	p3	19	16.1	9.4	11.6		
		p4	15.9	14.5	12	11.5		
		m1	21.5	21.5	13			
		m2				14		
MDLCA 23585	d	p4						
		m1						
		m2	24	21				
MDLCA 23586	s	m2						
		m3			14.5	13.1	7.4	40
MDLCA 23590	d	p3	19	16.5	9	11		
MDLCA 23591	s	p2	14.1	12	7.1	8		
MDLCA 23592	d	m2				12.1		
MDLCA 23593	d	m2	25	21				
MDLCA 23594a	d	M3				21.9		

Tab. 4 - Measurements (in mm) of the teeth and hemimandibles of *Praemegaceros* (*Nesoleipoceros*) *cazioti* of Su Concali Quarry.

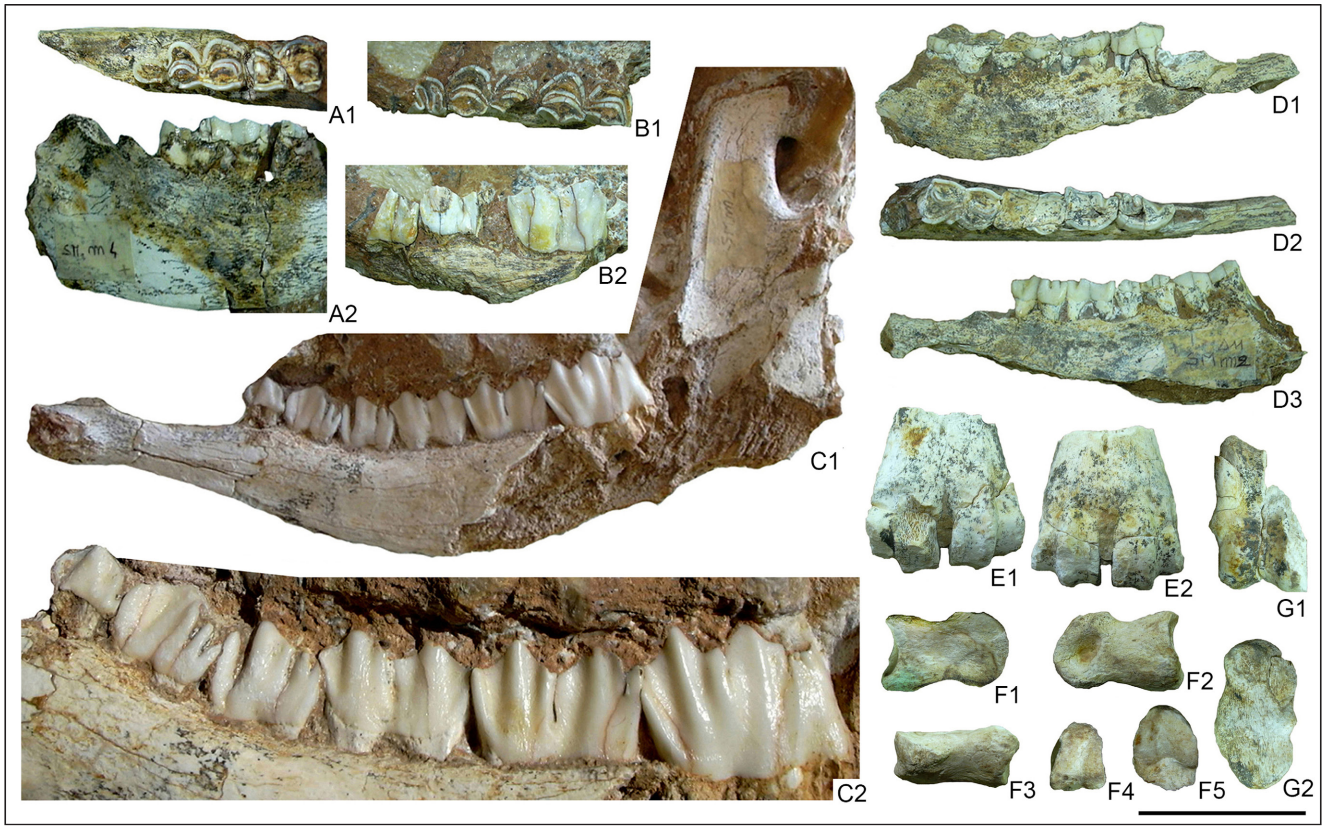

Fig. 10 - *Praemegaceros* (*Nesoleipoceros*) *cazioti* from Su Concali Quarry. A) MDLCA23586, incomplete left hemimandible with m2-m3 in occlusal 1) and lingual 2) views. B) MDCA23585, incomplete right hemimandible with p4-m2 in occlusal 1) and lingual 2) views. C) MDLCA23583, left hemimandible with p2-m3 in lingual 1) view and detail of the teeth 2). D) MDLCA23584, incomplete right hemimandible with p3-m2 in buccal 1), occlusal 2) and lingual 3) views. E) MDLCA23605, distal fragment of metapodial in posterior 1) and anterior 2) views. F) MDLCA23611, second phalanx in abaxial 1), axial 2), dorsal 3), distal 4) and proximal 5) views. G) MDLCA23607, incomplete left astragalus in anterior 1) and lateral 2) views. Scale bar = 5 cm, except for C2 = 2.5 cm.

tively abundant; however, the samples are generally poorly preserved and are represented by isolated teeth, fragments of hemimandibles and incomplete limb bones (Fig. 10). Furthermore, a conspicuous number of indeterminable small bone fragments was found in all levels of the fissure filling. Nevertheless, it was possible to take some linear measurements from the most complete bones and teeth (Tab. 4). The greater part of the samples probably belongs to female specimens, in fact, antlers or relatively large bones referable to male specimens were not found. The collected bones belong to adult and old individuals as shown by the teeth wear in the sample MDLCA23584 (Fig. 10D).

Megacerine are relatively common in the Quaternary fossil record of the Corso-Sardinian massif. Two species are reported in Sardinia: *Praemegaceros* (*Nesoleipoceros*) *cazioti* (Depéret, 1897) and *Praemegaceros* (*Nesoleipoceros*) *sardus* (Van der Made & Palombo, 2006). *P.* (*N.*) *sardus* is considered the bigger sized (about 25-40%) ancestor of the most common and recent *P.* (*N.*) *cazioti*. *Praemegaceros solilhacus* (Robert, 1830) is considered the mainland ancestor of this insular lineage (Vislobokova 2013).

The deer remains of Su Concali Quarry are comparable in size with the Late Pleistocene samples of Medusa/Dragonara Cave (Caloi & Malatesta 1974) and are assigned to the most recent megacerine species *P.* (*N.*) *cazioti*.

Discussion and conclusions

The Su Concali Quarry mammal assemblage includes the following taxa: *Microtus* (*Tyrrhenicola*) *henseli*, *Rhagamys orthodon*, *Prolagus sardus*, *Asoriculus* sp., *Cynotherium sardous* and *Praemegaceros* (*Nesoleipoceros*) *cazioti*. These mammals are well known in several Quaternary localities of the Corso-Sardinian massif.

The presence of Cervidae, Canidae and Arvicolinae excludes the *"Nesogoral"* Faunal Complex

in favor of the most recent *"Microtus (Thyrrhenicola)"* Faunal Complex.

The morpho-dimensional analysis of the collected taxa seem to indicate the typical mammal assemblage of the Late Pleistocene (Dragonara Faunal Subcomplex) and furthermore, the absence of taxa introduced by man tend to exclude an early Holocene age. In conclusion, the fissure filling of Su Concali Quarry represents the richest Quaternary mammals deposit reported in the central Campidano.

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