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Research Article

The Gelasian (Late Villanyan-MN17) diversified micromammal assemblage with *Mimomys pliocaenicus* from Coste San Giacomo (Anagni basin, central Italy), taxonomy and comparison with selected European sites

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Abstract

The Gelasian site of Coste San Giacomo (CSG) (central Italy) provides a unique opportunity to investigate the faunal and environmental changes occurred in Mediterranean Europe during the Early Pleistocene. The finding of both large and small mammal fauna has a great biochronological and palaeoenvironmental value.

In this work the description of the small mammal assemblage is presented and discussed in detail for the first time. Twelve taxa, belonging to three orders, have been in fact identified and described (six Rodentia, one Lagomorpha and five Eulipotyphla). In particular, the CSG small mammal assemblage has provided the largest collection in Europe of *Mimomys pliocaenicus* and, for this reason, it can be considered as a reference. Finally, the occurrence of the Desmaninae subfamily is reported for the first time in Italy.

Introduction

The Anagni Basin (central Italy) is a Plio-Pleistocene intermontane basin in the Italian peninsula, which developed largely between the Late Pliocene and the early part of the Middle Pleistocene (Carrara et al., 1995; Galadini and Messina, 2004). The sequence includes lacustrine-alluvial sediments covered by travertine (Segre and Ascenzi, 1984) and by Middle Pleistocene pyroclastic rocks. In this basin, from the Coste San Giacomo (CSG) site (Fig. 1), an Early Pleistocene (Gelasian) diversified large mammal assemblage referable to the Middle Villafranchian have been discovered and studied (Segre Naldini et al., 2009; Bellucci et al., 2012, 2014).

The drilling of a 46-m-deep core performed in 2009 and recent excavations (2011 and 2013) coordinated by the Earth Science Department of "Sapienza - University of Rome" (Raffaele Sardella) and the Italian Institute of Human Palaeontology (Fabio Parenti - IsIPU) have provided new palaeomagnetic, pollens, ostracods and small vertebrates remains. These data have been integrated with the updated list of the large vertebrates analysis in a multidisciplinary perspective and illustrated in Bellucci et al. (2014). The fossiliferous horizon was detected in the core at about 5 m below the ground surface. Magnetostratigraphy, pollen and small mammal biochronological data suggest an age around 2.1 Ma for the mammal assemblage of the Coste San Giacomo Faunal Unit, in a reversed phase before the base of the Olduvai chron (Bellucci et al., 2014).

In particular, the occurrence of the large vole *Mimomys pliocaenicus* has important biochronological significance. In this paper a detailed analysis of a diversified small mammal assemblage is presented and its biochronological and palaeoecological importance (Van Kolfschoten and Markova, 2005) is also illustrated. In the Italian peninsula only two sites are referable to the Late Villanyian: CSG and Rivoli Veronese but, only in the CSG faunal assemblage large and small mammals have been found together.

Materials and methods

The fossils discussed in this work were collected during the 2011 and 2013 field excavations. In particular, during the field excavation performed in 2013, the systematic sieving of the sediments, with mesh sieves of 1 and 0.5 mm, allowed to collect a large amount of small vertebrate remains. The complete list of small mammals comprise 384 fossils determined at the genus or specie level. Among these, 107 are indeterminable rooted molar fragments of voles and, according to their dimensions, have been ascribed to *Mimomys* sp.

In Tab. 1 are reported the number of remains (NR), the minimum number of individuals (MNI) of the complete fauna remains (Rodents, with *Castor* and *Hystrix*, and the Eulipotyphla).

The nomenclature used in the paper is taken from Sala et al. (1994); Tesakov (1998); Sulimsky (1964); Van Weers (1994); Angelone (2008); Fanfani and Masini (1997); Rümke (1985).

The measurements were taken, using a digital micrometer Parker Hannifin-decadal, according to Sala et al. (1994) for arvicolids, to

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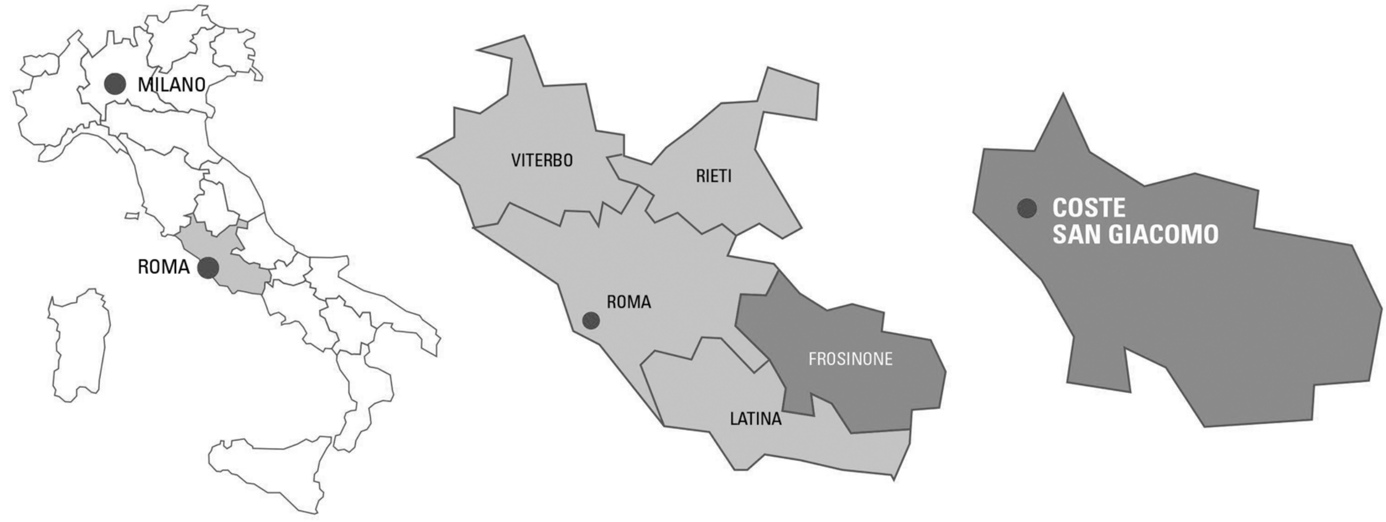

Figure 1 – Geographical position of Coste San Giacomo site.

Sulimsky (1964) for *Sciurus*, to Van Weers (1994) for *Hystrix*, to Angelone (2008) for *Prolagus*, to Fanfani and Masini (1997) and Rümke (1985) for Eulipotyphla.

The small mammal collection is now housed at the IsIPU laboratory in Anagni.

Systematic paleontology

Order Rodentia
Family Cricetidae FISHER, 1817
Subfamily Arvicolinae GRAY, 1821
Genus *Mimomys* FORSYTH-MAJOR, 1902
Mimomys pliocaenicus FORSYTH-MAJOR, 1902
Plate 1, Figs. 1, 2, 3, 4
Material: 39 M/1 (CSG 1-4, 32-33, 36, 38-40, 62-72, 74-77, 79, 81-85, 89-94, 96, 208); 29 M/2 (CSG 13-15, 41-43, 56-57, 60, 124-129, 138-139, 154, 169-1772, 182, 200-203, 215, 237); 18 M/3 (CSG 16-18, 130, 142-143, 173, 184-185, 205-207, 212-213, 231-232, 239-240); 41 M1/ (CSG 5-9, 44-46, 61, 98-104, 112, 133-135, 146-149, 164-165, 178-181, 187-193, 214, 217, 222-223); 38 M2 (CSG 10-12, 47-50, 54-55, 113-123, 136-137, 152-153, 166-167, 176, 183, 194-196, 210, 218-220, 224, 235-236); 24 M3 (CSG 30-31, 59, 105-111, 140, 156-159, 163, 197, 211, 225-230); 7 hemi-mandibles (two specimens without the teeth and four with at least the M/1) (CSG 34, 73, 78, 80, 87-88, 258).

The dentine fields show a moderate confluence and the differentiation of the enamel thickness presents the "*Mimomys*" or negative type. The crown cement occurs, abundant in older and moderate in younger specimens. The anteroconid complex is fairly simple and the "*Mimomys* ridge" is always present. In the younger specimens a well-developed islet occurs, absent in the older specimens.

The hyposinuid and hyposinulid reach the occlusal surface in the adult to old individuals whereas in few young to very young specimens the hyposinulid does not reach the occlusal surface. This has been observed in all the complete teeth. The length of the m1 spans from 2.98 mm to 3.7 mm with an average of 3.31 mm (Tab. 2).

Table 1 – List of small mammals remains from Coste San Giacomo (NR = numbers of remains; %NR = percentage of NR; MNI = minimum numbers of individual estimated; %MNI = percentage of MNI).

Taxon	NR	%NR	MNI	%MNI
Rodentia				
Apodemus sp.	1	0.36	1	1.89
Mimimys pliocaenicus	228	82.61	20	37.74
Mimomys gr. *tigliensis/tornensis*	6	2.17	3	5.66
Sciurus cf. *wartae*	1	0.36	1	1.89
Castor fiber	2	0.72	2	3.77
Hystrix refossa	7	2.54	4	7.55
Lagomorpha				
Prolagus italicus	10	3.62	4	7.55
Eulipotyphla				
Beremendia fissidens	6	2.17	6	11.32
Soricinae indet.	1	0.36	1	1.89
Sorex cf. *minutus*	1	0.36	1	1.89
Galemys kormosi	3	1.09	3	5.66
Talpa minor	8	2.90	5	9.43
Talpa sp.	3	1.09	3	5.66
Total	276	100	53	100

Table 2 – Measurements of lower first molar of *Mimomys pliocaenicus* from CSG (L: maximum occlusal length; W: maximum occlusal width; AL: anteroconid length; LHC: lingual height of the crown; A/L: (A/L)/L. Measures in mm).

M/1	n	max	min	sd	mean
L	25	3.70	2.86	0.23	3.31
W	37	1.77	0.98	0.15	1.42
AL	32	1.75	1.23	0.14	1.47
LHC	19	5.69	1.84	1.17	4.02
A/L	21	47.60	37.89	2.86	44.00

The great hypsodonty of the m1 of CSG permits to discard its attribution to *Mimomys polonicus*; the dimensions fall within the range of *Mimomys pliocenicus* (Tesakov, 1998; Sala et al., 1994). The M/1 seems to be smaller and it shows a less evolved sinuous line than *Mimomys ostramosensis* (Carls and Rabeder, 1988). The first lower molars of CSG show more archaic features than the holotype if compared with *Mimomys pliocaenicus* from Castelfranco di Sopra (see Fig. 3, drawing 2 in Masini and Torre, 1987). The Castelfranco di Sopra specimen is in fact more similar to *Mimomys ostramosensis* than to *Mimomys pliocaenicus* of Tegelen considering the development of the sinuous line. It is worth noting that the CSG large *Mimomys* specimens represent the largest collection of this arvicolid species and therefore can be considered as a reference. A detailed work on the morphological and biometrical data of *Mimomys pliocaenicus* from CSG is in progress.

Mimomys gr. *tigliensis-tornensis*
Plate 1, Figs. 5, 6

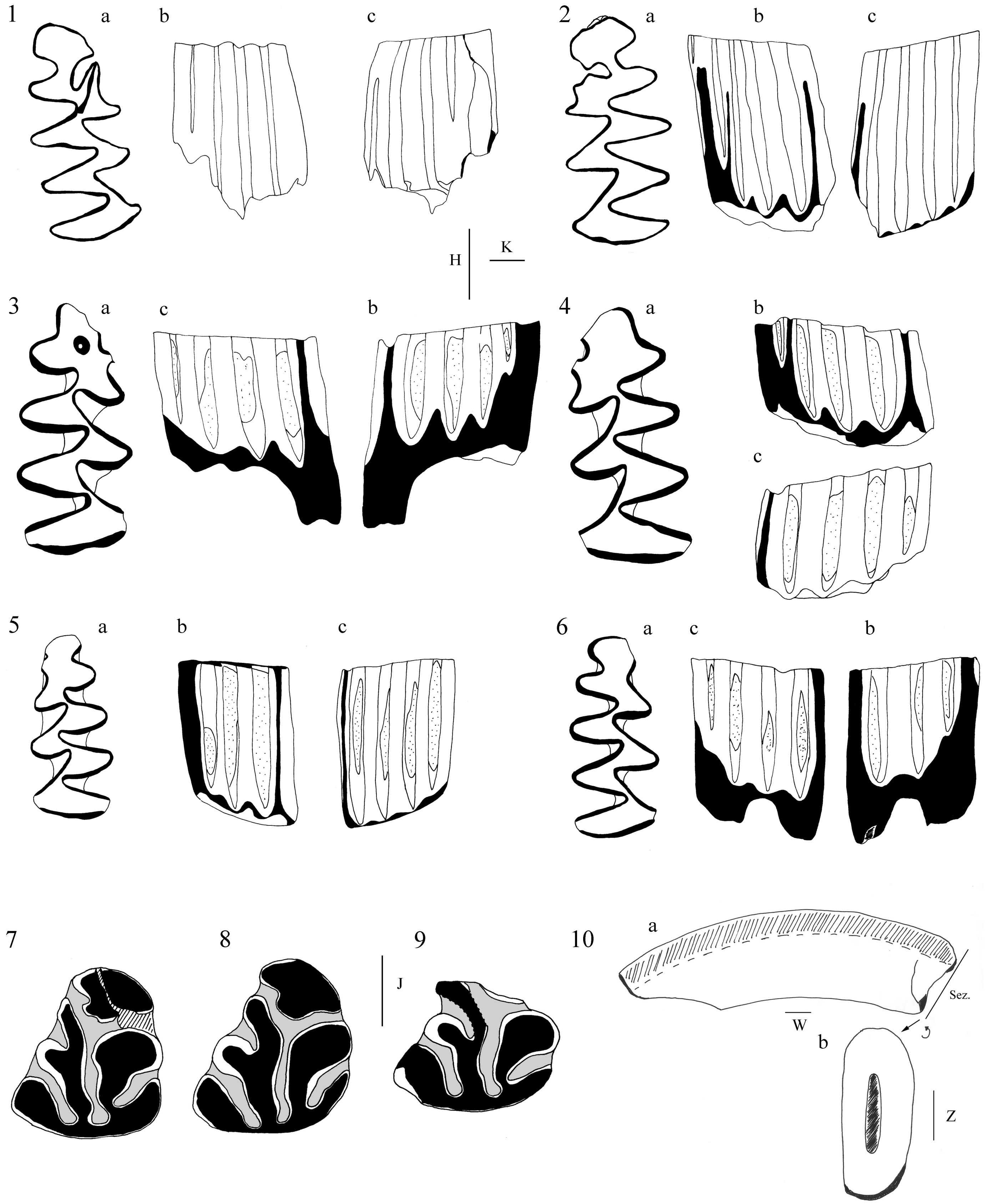

Plate 1 – *Mimomys pliocaenicus*: 1-4, four different age development; 1 – M/1 right, very juvenile specimen (CSG 81); 2 – M/1 left, juvenile speciment (CSG 94); 3 – M/1 right, adult specimen (CSG 84); 4 – M/1 left, senile specimen (CSG 91). *Mimomys* gr. *tigliensis-tornensis*: 5 – M/1 left (CSG 95); 6 – M/1 right (CSG 97). a: occlusal view; b: lingual view; c: buccal view. H-K: scale bar = 1 mm, H occlusal view and K lateral view. *Prolagus italicus*: 7 – P/3 left (CSG 265); 8 – P/3 left (CSG 266); 9 – P/3 left (CSG 269). J: scale bar = 1 mm. *Sciurus* cf. *warthea*: 10 lower right incisive tooth. a: lateral view; b: section. W-Z: scale bar = 1mm, W lateral view and Z section.

Material: 3 M/1 (CSG 86, 95, 97); 2 M/2 (CSG 145, 204); 1 M3/ (CSG 141).

The small representatives of the genus *Mimomys* are very scarce in the Coste San Giacomo collection, being the ratio of small *Mimomys* M/1 to *M. pliocaenicus* M/1 is 1 to 13. This fact is quite unusual, since in other coeval sites in Europe (Tegelen, Rivoli Veronese, etc.) the small *Mimomys* teeth are more numerous than those of the large *Mimomys pliocaenicus*. At Rivoli Veronese the ratio is 1 to 7 (Sala et al., 1994) and at Tegelen is 1 to 4 (Tesakov, 1998). Large arvicolids are usually less represented than the small ones also in the Middle and Late Pleistocene sites where the ratio *Arvicola*/*Microtus* is always much less than one (see for example: Fontana Marella cave – Bona et al., 2008; Caverna Generosa – Bona et al., 2009; Salnova quarry – Bona, 2011). This peculiar ratio in the CSG collection, considering the good accuracy of the sieving, may be due to the environmental condition surely more favourable to the large *Mimomys*.

The two complete first lower molars of the small *Mimomys* show a mix of features between two very similar species: *M. tigliensis* and *M. tornensis*. In particular, the small specimen CSG-95 shows all the typical dimensions and features of *M. tigliensis*: abundant cement in the re-entrant angles lacking the enamel islet, prominent *Mimomys*-ridge in younger stages of wear, rounded anterior cap of the anteroconid (Tesakov, 1998, Fig. 24 numbers 5 and 6). On the other hand, the specimen CSG 97 shows the *M. tornesis* size and features (Tab.3). According to Tesakov (1998) *M. tornensis* differs from *M. tigliensis* in the following features: larger size, more advanced hypsodonty, lower percentage of *Mimomys*-ridge occurrence and less developed roots.

At the present day it is neither possible to ascribe our specimens to *M. tigliensis* or *M. tornensis* nor to establish the contemporary occurrence of these two taxa.

Table 3 – Measurements of lower first molar of *Mimomys* gr. *tornensis-tigliensis* from CSG (L: maximum occlusal length; W: maximum occlusal width; AL: anteroconid length; LHC: lingual height of the crown; A/L: (A/L)/L. Measures in mm).

M/1	n	max	min	sd	mean
L	2	2.86	2.58	0.20	2.72
W	2	1.14	1.05	0.06	1.10
AL	2	1.30	1.16	0.10	1.23
LHC	2	3.90	3.03	0.54	3.52
A/L	2	45.45	44.96	0.35	45.21

Family Muridae GRAY, 1821
Genus *Apodemus* KAUP, 1829
Material: 1 damaged left hemi-mandible without teeth (CSG 23)

The specimen CSG 23 is a horizontal ramus of left hemi-mandible without teeth. The overall morphology and distribution of the alveoli, six in line, allow to ascribe this fossil remain to *Apodemus* sp.

Family Gliridae THOMAS, 1897
Genus *Sciurus* LINNAEUS, 1758
Sciurus cf. *S. warthae* SULIMSKY, 1964
Plate 1, Fig. 10
Material: 1 right lower incisor (CSG 22)

The dimensions (antero-posterior diameter: 3.52 mm; transverse diameter: 1.60 mm) and the overall morphology permit a positive comparison of CSG 22 with the remains of *Sciurus warthae* from Weze I (Sulimsky, 1964). The measurements of CSG 22 clearly fall within the range of *Sciurus warthae* and the broad transversal diameter strengthens this determination.

Family Castoridae HEMPRICH, 1820
Genus *Castor* LINNAEUS, 1758
Castor fiber LINNAEUS, 1758
Material: 2 right M/1-2 (CSG 25, CSG 242)

The hypoflexid does not reach the half of the tooth width and it is slightly curved backwards. The paraflexid and the mesoflexid are coalescent forming an oval island between the flexids. The absence of secondary enamel folds permits to rule out its attribution to the subspecies *Castor plicidens* (*Castor fiber plicidens* Barisone et al., 2006). The measurements of the specimen are CSG 25: L= 9.7 mm, W= 9.8 mm; CSG 242: L= 8.7 mm, W= 9.1 mm.

Family Hystricidae Burnett, 1830
Genus *Hystrix* LINNAEUS, 1758
Hystrix refossa GERVAIS, 1852
Material: 2 left M1/ or M2/ (CSG 243, 244), 1 left DP/4 (CSG 28), 1 left P/4 (CSG 29), 1 P/4? (not well preserved -CSG 245-), 1 right M/1 or M/2 (CSG 247), 1 right M/3 (unworn and rootless -CSG 246-)

The permanent teeth are strongly hypsodont (Tab. 4) and fit perfectly fit within the *Hystrix refossa* range (Van Weers, 1994; Rook and Sardella, 2005); the teeth are larger than *H. vinogradovi* and they are similar in size to those of *H. primigenia* but they are more hypsodont.

The analysis of the wear stage (reported according to Van Weers and Rook, 2003) allows to hypothesize the occurrence of 4–5 individuals at least (Tab. 4, last line).

The deciduous DP/4 (CSG 28) shows a high wear stage on the occlusal surface with seven enamel islands and a very low crown, testified by E/L index (Tab. 4). The two M1/ or M2/ are teeth with three roots folded in the bucco-lingual direction of different wear stage and with quite different dimensions (Tab. 4); the occlusal surface shape ranges from sub-quadrangular to sub-rectangular. The P/4 (CSG 29) shows a sub-rectangular occlusal surface and an intermediate wear stage with three folds and three islands; the crown is straight and well developed. The M/1 or M/2 is large and slightly bent in bucco-lingual direction; the occlusal surface has a sub-rectangular shape.

Table 4 – Measurements of *Hystrix refossa* teeth (L: maximum occlusal length; W: maximum occlusal width; E: enamel buccally maximum length; El: enamel lingually maximum length; E/L: (E/L)×100. Measures in mm).

	28	29	243	244	245	246	247
	DP/4	P/4	M1/ or M2/	M1/ or M2/	P4/?	M/3	M/1 or M/2
L	8.9	10.2	9.0	10.3	8.8	10.1	10.4
W	7.1	8.0	7.3	10.2	6.3	7.5	8.5
E	8.0	14.6	11.8	10.9		14.0	14.3
E1	6.6	15.9	19.0	17.8		15.1	
E/L	90	143	131	106		139	137
Wear class	T	Q-R	D	G		O	R-S

Order Lagomorpha
Family Ochotonidae THOMAS, 1897
Genus *Prolagus* POMEL, 1853
Prolagus italicus ANGELONE, 2008
Plate 1, Figs. 7, 8, 9
Material: 4 P/3 (CSG 265, 266, 267, 269), 4 fragments of P/4 or M/1 or M/2 (CSG 268, 272, 273, 274), 1 P2/ (CSG 271)

The morphological features of the P/3 permit to attribute the CSG Lagomorpha to the genus *Prolagus* and, in particular, to *Prolagus italicus* ANGELONE, 2008. The characteristics of the P/3 are: i) all P/3 lack the crochet, in holotype population described by Angelone (2008) the crochet occurs in more than 50% of samples; ii) the hypoconid and the entoconid are well developed; iii) the mesoflexid is developed and has a "S" shape; iv) the Anteroconid is sub-triangular and well developed; v) the Metacone and Anterocone have approximately the same dimensions; vi) the Protoconid is undeveloped vii) the Protoconulid is developed; viii) the P/3 fall in the dimensional range (Tab. 5) of *P. italicus* whereas they are slightly larger than of *P. savagei* and *P. sorbini*.

The P2/ is not well preserved but the overall morphology shows characters similar to those highlighted by Angelone (2008) for *P. italicus*. The fragments of molars are poorly preserved and not allow further analyses.

Order Eulipotyphla
Family Soricidae GRAY, 1821

Table 5 – Measurements of *Prolagus italicus* teeth (L: maximum occlusal length; W: maximum occlusal width. Measures in mm).

P/3	CSG 265	CSG 266	CSG 267	CSG 269	TP*	MS*
L	2.41	2.28		2.42	2.03	2.17
W	1.98	2.03	1.86	2.13	2.10	2.63

P2/	CSG 271	TP*	MS*
L	1.40	1.20	1.51
W	2.00	1.65	2.30

* average data from Angelone (2008), TP means "Cava Toppetti" and MS means "Montagnola Senese".

Subfamily Soricinae FISHER, 1817
Soricinae indet.
Plate 2, Fig. 9
Material: 1 damaged right hemi-mandible with alveoli of M/2-3 (CSG 53)

The specimen CSG 53 is not well preserved; it lacks all the teeth and about the mesial half of the horizontal ramus. The morphology of CSG 53 is similar to that of CSG 20 but CSG 53 is significantly smaller (Tab. 6).

Table 6 – Measurements of Soricidae remains (I/1. L: length of crown. Hemi-mandible. H: height of ascending ramus; L: length from point P to mental foramen (see **?**); L1: length from point P to end of I/1 alveolus; S1, S2, S3: height of the horizontal ramus in correspondence of the distal end of M/1, M/2 and M/3 respectively; M1, M2, M3: length of M/1, M/2 and M/3; SA1, SA2, SA3: width of the trigonid of M/1, M/2 and M/3; SP1, SP2, SP3: width of the talonid of M/1, M/2 and M/3; Condyle. LUF: length of upper condilar facet; LLF: length of lower facet; HC: maximum height of condyle. Measures in mm.

I/1	CSG 262	CSG 263		
L	5.57	6.11		
Hemimandible	**CSG 20**	**CSG 261**	**CSG 53**	**CSG 275**
H				3.22
L				5.44
L1				4.74
S1		2.05		0.74
S2		2.42		0.85
S3		2.71	2.09	0.97
M1		2.95		
SA1	1.50	1.51		
SP1		1.64		
M2	2.58*	2.49	1.74*	1.04
SA2		1.55		0.69
SP2		1.46		0.74
M3	1.51*	1.60	1.37*	
SA3		1.12		
SP3		0.87		
M1-M3	5.67*			
TI				0.82
TM3				2.11
Condyle				
LUF				0.53
HC				0.97
LLF				0.77

* alveolar length.

Tribe Beremendiini REUMER, 1984
Genus *Beremendia* KORMOS, 1934
Beremendia fissidens PETÉNYI, 1864
Plate 2, Figs. 8, 10, 11
Material: 3 damaged right hemi-mandibles: 1 horizontal ramus with fragmented M/1 (CSG 20), 1 horizontal ramus with M/1-3 (CSG 261), 1 fragmented distal portion with alveoli of M/2-3 (CSG 264); 3 right I/1 (CSG 21, 262, 263)
Measurements: see Tab. 6

The incomplete right hemi-mandible CSG 20 is very large, showing a robust morphology and the fragmented M/1 has an intense dark red colouration. Specimen CSG 261 is similar to CSG 20, but it is better preserved, conserving the M/1, M/2 and M/3. According to the dimensions and the overall morphology described by many authors (e.g., Sala et al., 1994; Rzebik-Kowalska, 1976) it is possible to ascribe the specimens CSG 20, 261, 264 to *Beremendia fissidens*. CSG 262 and CSG 263 are well preserved I/1. They are acuspidate large teeth, long, knife-shaped with apex curved up and strongly coloured. There is a characteristic thin cingulum on the posterior dorsal margin of the buccal side. CSG 21 is a very small fragment of I/1 but according to its relative dimension and to the very dark red colour, it can be assigned tentatively to *Beremendia* cf. *fissidens*.

Tribe Soricini FISHER, 1817
Genus *Sorex* LINNAEUS, 1758
Sorex cf. *S. minutus*
Plate 2, Fig. 12
Material: 1 right hemi-mandible with half M/1 and a complete M/2 (CSG 275)
Measurements: see Tab. 6

The hemi-mandible, despite the absence of redness on the teeth cusps, has a slender horizontal ramus with a very thin symphysis portion, which contrasts with others crocidurinae shrews of similar size, like *Suncus*. According to these features, CSG 275 is attributable to the genus *Sorex*. The mandibular ramus is low and the central part of its lower border is concave. The condyle presents a small upper facet that is large, if compared to others soricinae, and it bends down on the lingual side and a broad interarticular area. The mental foramen is located below the first root of M/1. According to the hemi-mandible and teeth sizes, it is possible to attribute the specimen, with some doubts, to *Sorex* cf. *minutus*.

Sorex minutus is one of the smallest representative of the genus *Sorex*. This shrew species was widespread in Europe since the earliest Pliocene (Rzebik-Kowalska, 1998). The *S. minutus* of CSG therefore represents the oldest finding in the Italian peninsula. Until now, in Italy, *S. minutus* had been only reported in the Early Biharian sites of Monte La Mesa (Marchetti et al., 2000).

Family Talpidae FISCHER, 1817
Subfamily Talpinae FISCHER, 1817
Tribe Talpini FISCHER, 1817
Genus *Talpa* LINNAEUS, 1758
Talpa minor PETÉNYI, 1864
Plate 2, Figs. 6, 7
Material: 3 hemi-mandibles (CSG 37 is a left mesial portion of horizontal ramus with P/2, P/4 and M/1, CSG 251 -left- and CSG 253 -right- are fragments of horizontal ramus without teeth), 3 ulna fragments (2 right and 1 left), 1 left radius distal fragment, 1 left M/1.

All morphological characters shown by specimen are typical of *Talpa* genus, the size of the hemi-madibular fragments and post-cranial elements are smaller than those of *Talpa europaea* LINNAEUS, 1758 and they fall within the range of the *minor-caeca* group (Tab. 7).

Talpa sp.
Plate 2, Figs. 3, 4, 5
Material: 2 damaged humeri, 1 right (CSG 26) and 1 left (CSG 27), 1 mesial fragment of right hemi-mandible with p1 (CSG 260).

The two humeri are heavily damaged and it has been possible take only a few measurements. These measurements (Tab. 7) fall within the range of *Talpa* cf. *T. fossilis* from Monte Peglia (Van der Meulen, 1973), but also with that of *Talpa* cf. *T. minor* from Monte La Mesa (Marchetti et al., 2000). New finds are necessary to give more precise information about the taxonomic status of the Coste San Giacomo moles.

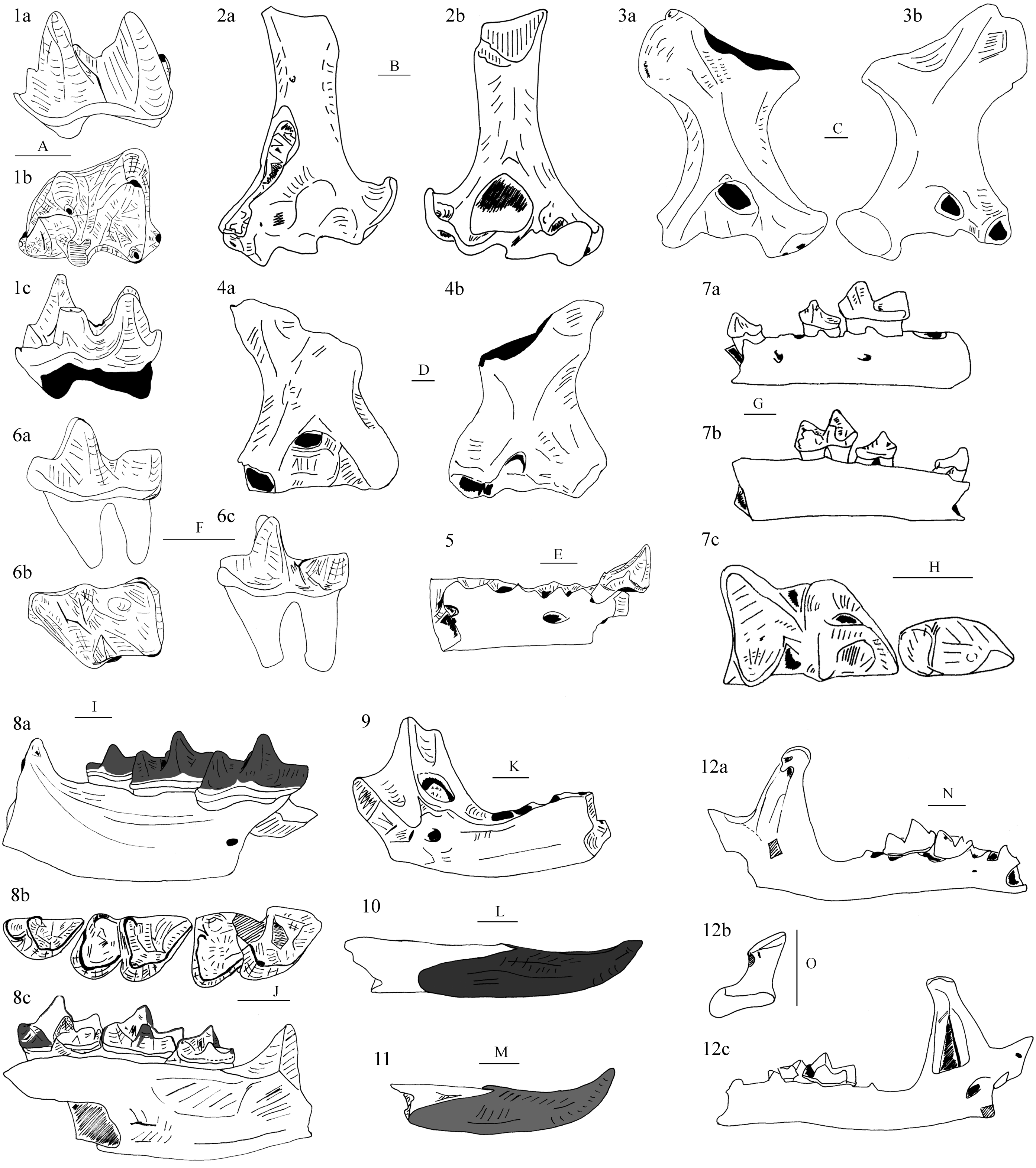

Plate 2 – *Galemys kormosi*: 1 – right M/2 (CSG 259) (A); 2 – left humerus (CSG 24) (B). *Talpa* sp.: 3 – right humerus (CSG 26) (C); 4 – left humerus (CSG 27) (D); 5 – right hemi-mandible fragment with P/1(CSG 260) (E). *Talpa minor*: 6 – left M/1 (CSG 254) (F); 7 – left hemi-mandible fragment with with P/2, P/4 and M/1 (CSG 37) (G). Soricinae indet.: 9 – left hemi-mandible fragment without teeth (CSG 53) (K). *Beremendia fissidens*: 8 – right hemi-mandible with M1-M3 (CSG 261) (I: lateral view, J: occlusal view); 10 – right lower Incisive (CSG 283) (L); 11 – right lower Incisive (CSG 262) (O). *Sorex* cf. *minutus*: 12 – right hemi-mandible with M1-2 (CSG 275) (N: lateral view, O: condyle view). All scale bar are 1 mm (in capital letter in the brackets at the end of the description of specimen).

Table 7 – Measurements of Talpidae remains (Hemi-mandible and teeth. S1: height of the horizontal ramus in correspondence of the distal end of M/1; M1, M2: length of M/1 and M/2; SA1, SA2: width of the trigonid of M/1 and M/2; SP1, SP2: width of the talonid of M/1 and M/2; P4: length of P/4; SP4: width of P/4; P1: length of P1; P1W: width of P/1. Measures in mm).

Humerus	CSG 26	CSG 27	CSG 24	
Minimum width	3.23	3.88		
Distal width	6.96		5.67	
Hemimandible and M/1	**CSG 37**	**CSG 254**	**CSG 52**	**CSG 259**
S1	2.06			
M1	2.13	1.84		
SA1	1.24	1.19		
SP1	1.41	1.10		
M2			2.35	2.40
SA2			1.42	1.45
SP2			1.67	1.75
P4	1.39			
SP4	0.69			
P1	1.11			
P1 W	0.53			

Subfamily Desmaninea RÜMKE, 1985
Genus *Galemys* KAUP, 1829
Galemys kormosi (SCHREUDER, 1940)
Plate 2, Figs. 1, 2
Material: 1 distal half of left humerus (CSG 24); 2 M/2, 1 right (CSG 259) and 1 left (CSG 52).

The M/2 show the typical talpids morphology. The cusps are sturdy than in the genus *Talpa*. The oblique crista is long and it reaches the metaconid tip. A strong anterior cingulum is present, widening just before reaching the lingual border forming a kind of parastylid. A strong entostylid is present on the posterior side.

The humerus shows a shape not typical of fossorial talpids but typical of all representatives of this subfamily (Rümke, 1985). The bone preserves a few more that the distal half with a narrow diaphysis and an enlarged distal epiphysis.

The morphology and the dimensions (Tab. 7) fall in the range of the *Galemys kormosi*, in particular with the *G. kormosi* from Tegelen (Rümke, 1985).

Therefore, the CSG water mole findings represent the first report of the Desmaninae subfamily in Italy.

Discussion and final remarks

Rodents are very important elements in fossil mammal faunal assemblages and, among them, arvicoline have an extraordinary biochronological value. The evolutionary lineage including the Pliocene-Early Pleistocene *Mimomys* (with rooted molars) and the Middle to Late Pleistocene *Arvicola* (with not rooted molars) is of crucial importance for defining a biochronological scheme at an European scale (Maul et al., 1998). Since *Mimomys pliocaenicus* characterizes the earliest Pleistocene micromammal assemblages the occurrence of the rich sample at CSG is of particular interest and provides a valuable amount of biochronological and palaecological information.

The morphology of the lower first molar of the large vole *Mimomys pliocaenicus* permits to compare the CSG teeth with those from other Italian and European sites such as Osztramos 3 (Hungary) and, Tegelen (The Netherland). The large *Mimomys* of CSG shows a greater hypsodonty than the archaic species *Mimomys hajnackensis* and *Mimomys polonicus* (Sabol et al., 2006; Mayhew et al., 2008). At the same time, it seems to be more brachyodont than the type specimen of *M. pliocaenicus* from Castelfranco di Sopra (Upper Valdarno, Tuscany) correlated with the Olivola FU (Gliozzi et al., 1997), and therefore it is considered less advanced.

According to Masini and Torre (1987), the type of *M. pliocaenicus* is comparable in size and hypsodonty degree to *Mimomys ostramosensis* from Osztramos 3 (for discussion see Sala et al., 1994. The *Mimomys pliocaenicus* of CSG can also be compared with *Mimomys* cf. *pliocaenicus* of Rivoli Veronese (Sala et al., 1994) and the specimens of Tegelen (Tesakov, 1998), attributed to the Middle Villafranchian or Late Villanyian Small Mammal Age (Fejfar and Heinrich, 1990). Compared with the minor degree of hypsodonty seen in *Mimomys* of Castelfranco di Sopra, the *M. pliocaenicus* of CSG can be considered therefore older than the Olivola FU (Tab. 8). This is in accordance with the age inferred from the study of the large mammals of the site, FU Coste San Giacomo (Gliozzi et al., 1997).

The CSG small mammal faunal assemblage provides important and new data on the biochronology and palaeoenvironment of the Mediterranean fauna during the Gelasian (Early Pleistocene).

In Tab. 8 is presented a detailed comparison between CSG and some selected European Late Villanyan/Early Biharian sites. It is worth noting that the Eastern European small mammal taxa are absent in the CSG mammal assemblage. Thereafter the CSG small mammals fauna represents, during the Early Pleistocene in central Italy, a phase prior to the expansion of eastern taxa into South-western Europe as demonstrated by the lack of the genera *Villanyia*, *Ungaromys*, *Dinaromys* and *Ellobius* that are present among others at Rivoli Veronese (Sala et al., 1994) in the North-eastern Italy. The occurrence of the endemic *Prolagus* also strengthens this hypothesis. Moreover, the CSG fauna confirms the persistence in central Italy of environmental conditions, maybe characterized by a less continental climate than Rivoli Veronese, that have retarded the distribution of Eastern taxa already present in North Italy.

The association of both small and large mammalian assemblages is of great and unique biochronological importance and confirms the correlation of the CSG mammal assemblage at the end of the Middle Villafranchian and at the end of Villanyan (Masini and Sala, 2007, 2011), in a crucial moment influenced by the diffusion of open environments, including steppe taxa, in the Mediterranean Europe (Bertini, 2010).

During the Gelasian the area of CSG was characterized by the presence of a braided streaming (data from geological and stratigraphical analyses, see Bellucci et al., 2014). The small and large mammal assemblage allowed to hypothesize that the surroundings of this watercourse was characterized by the presence of mainly grasslands, testified by the presence of abundant rests of *Equus stenonis* and abundant arvicolids. The wooded areas are, probably, in regressive phase; the last *Anancus* and the very poorly represented Eulipotyphla and Muridae testified the presence of reduced and unstructured covered areas. The humid environment is limited to the surroundings of the watercourse and it is characterized by the presence of the beavers, the hippopotamus, the large arvicolid *Mimomys pliocaenicus* and the water mole *Galemys kormosi*.

In conclusion, the new palaeontological data from the small mammals from CSG, in particular of large vole *Mimomys pliocaenicus*, have confirmed an age of the mammal assemblage older than Olivola FU (Gliozzi et al., 1997). Furthermore the small mammal assemblage provides evidence of the persistence in central Italy of environmental conditions that have retarded the distribution of Eastern taxa already present in Northern Italy. Finally, in this work, it has been reported for the first time, in Italian peninsula, the occurrence of the water mole *Galemys kormosi* belonging to the Desmaninae subfamily.

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Table 8 – Late Villanyan/Early Biharian selected European sites.

Site	Galera 2[1]	Barranco conejos[2]	Saint-Vallier[3]	Tegelen[4]	Schernfeld[5]	Kadzielinia 1[6]	Osztramos-3[7]	Coste San Giacomo[8]	Montagnola senese[9]	Rivoli Veronese[10]	Torre Picchio[11]	Casa Sgherri[12]	Monte la Mesa[13]
Age	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Early Biharyan
MN unit	MN17	MNQ1	MN17	MN17	MNQ1	MN17	MN17	MN17	MN17	MN17	MN17	MN17	MNQ1
Magnetostratigraphy		1.8–1.7 M.a.	2.58–1.95 M.a.					2.1 M.a.					
Country	Spain	Spain	France	The Nederlands	Germany	Poland	Hungary	Italy	Italy	Italy	Italy	Italy	Italy
Eulipotytphla													
Erinaceus sp.						•	•						•
Talpa fossilis			•			•	•		•				
Talpa minor				•		•		•		•			•
Talpa sp.								•		•			
Desmana thermalis				•									
Desmana inflata	•												
Desmana sp.							•						
Galemys kormosi				•				•					
Galemys cf. *kormosi*		•											
Asoriculus gibberodon			•							•			•
Beremendia fissidens			•	•		•	•	•		•			•
Blarinoides mariae													•
Crocidura sp.						•							•
Crocidura cf. *kornfeldi*							•						
Deinsdorfia hibbardi						•							
Petenya hungarica				•		•				•			•
Myosorex meini	•												
Urotrichus sp.						•							
Sulimskia kretzoii						•							
Sorex bor						•				•			•
Sorex minutus	•	•	•	•		•	•	•	•				•
Sorex sp.		•					•						
Sorex subaraneus						•							
Sorex prealpinus													•
Sorex (D.) praearaneus				•		•				•			•
Rodentia													
Allocricetus bursae													•
Allocricetus ehiki							•						•
Castor fiber			•					•					
Castor sp.												•	
Trogontherium cuvieri				•									
Histryx refossa			•	•				•				•	

References 1: Agusti et al., 2010; 2: Agusti et al., 2010; Agusti et al., 2013; 3: Guerin et al., 2004; Sen, 2004; Suarez and Mein, 2004; 4: van den Hoek Ostende and de Vos, 2006; 5: Carls and Rabeder, 1988; 6: Kowalsky, 1958; Rzebik-Kowalska, 2009; 7: Janossy and van der Meulen, 1975 Janossy, 1986; 8: in this paper; Bellucci et al., 2014; 9: Fondi, 1972; Maul et al., 1998; 10: Sala et al., 1994; 11: Girotti et al., 2003; 12: Marcolini, 2003; 13: Marchetti et al., 2000.

Table 8 – Late Villanyan/Early Biharian selected European sites (continued).

Site	**Galera 2**[1]	**Barranco conejos**[2]	**Saint-Vallier**[3]	**Tegelen**[4]	**Schernfeld**[5]	**Kadzielinia 1**[6]	**Osztramos-3**[7]	**Coste San Giacomo**[8]	**Montagnola senese**[9]	**Rivoli Veronese**[10]	**Torre Picchio**[11]	**Casa Sgherri**[12]	**Monte la Mesa**[13]
Age	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Early Biharyan
MN unit	MN17	MNQ1	MN17	MN17	MNQ1	MN17	MN17	MN17	MN17	MN17	MN17	MN17	MNQ1
Magnetostratigraphy		1.8–1.7 M.a.	2.58–1.95 M.a.					2.1 M.a.					
Country	Spain	Spain	France	The Nederlands	Germany	Poland	Hungary	Italy	Italy	Italy	Italy	Italy	Italy
Rodentia (continued)													
Apodemus atavus	•		•										•
Apodemus dominans												•	
Apodemus sp.		•		•			•	•	•	•			
Castillomys crusafonti	•												
Castillomys rivas		•											
Micromys cf. *praeminutus*							•						
Micromys sp.				•									
Prospalax priscus							•						
Sciurus warthae								•					•
Sciurus sp.				•		•				•			
Pliopetaurista										•			
Hylopletes debruijni				•									
Spermophilus primigenius				•			•						
Glirulus pusillus				•									
Glis sackdiligensis							•						•
Glis sp.										•		•	
Eliomys sp.		•											
Muscardinus sp.						•				•			
Muscardinus pliocaenicus				•									
Muscardinus cf. *dacicus*													•
Borsodia newtoni					•	•	•						
Clethrionomys sp.							•						•
Clethrionomys kretzoii				•	•	•							
Dinaromys allegranzii										•			
Dinaromys dalmatinum													•
Cf. *Ellobius*										•			
Kislangia gusii	•												
Lemmus kowalskii					•								
Lemmus cf. *lemmus*							•						
Microtus (A.) pliocaenicus													•
Mimomys sp.		•											

References 1: Agusti et al., 2010; 2: Agusti et al., 2010; Agusti et al., 2013; 3: Guerin et al., 2004; Sen, 2004; Suarez and Mein, 2004; 4: van den Hoek Ostende and de Vos, 2006; 5: Carls and Rabeder, 1988; 6: Kowalsky, 1958; Rzebik-Kowalska, 2009; 7: Janossy and van der Meulen, 1975 Janossy, 1986; 8: in this paper; Bellucci et al., 2014; 9: Fondi, 1972; Maul et al., 1998; 10: Sala et al., 1994; 11: Girotti et al., 2003; 12: Marcolini, 2003; 13: Marchetti et al., 2000.

Table 8 – Late Villanyan/Early Biharian selected European sites (continued).

Site	**Galera 2**[1]	**Barranco conejos**[2]	**Saint-Vallier**[3]	**Tegelen**[4]	**Schernfeld**[5]	**Kadzielinia 1**[6]	**Osztramos-3**[7]	**Coste San Giacomo**[8]	**Montagnola senese**[9]	**Rivoli Veronese**[10]	**Torre Picchio**[11]	**Casa Sgherri**[12]	**Monte la Mesa**[13]
Age	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Early Biharyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Late Villanyan	Early Biharyan
MN unit	MN17	MNQ1	MN17	MN17	MNQ1	MN17	MN17	MN17	MN17	MN17	MN17	MN17	MNQ1
Magnetostratigraphy		1.8–1.7 M.a.	2.58–1.95 M.a.					2.1 M.a.					
Country	Spain	Spain	France	The Nederlands	Germany	Poland	Hungary	Italy	Italy	Italy	Italy	Italy	Italy
Rodentia (continued)													
Mimomys ostramosensis					•							•	
Mimomys cf. *ostramosensis*							•						•
Mimomys pliocaenicus			•	•				•	•				
Mimomys cf. *pliocaenicus*										•			
Mimomys pusillus													•
Mimomys cf. *pusillus*			•										
Mimomys cf. *malezi*													•
Mimomys medasensis	•										•		
Mimomys coelodus												•	
Mimomys redai				•		•							
Mimomys gr. *tigliensis/tornensis*								•					
Mimomys tornensis					•					•			•
Mimomys tigliensis				•			•						
Mimomys pitymyoides				•	•				•	•		•	
Pliomys schernfeldensis					•		•						
Pliomys episcopalis						•							•
Tcharinomys oswaldoreigi		•											
Tibericola vandermeuleni		•											
Ungaromys sp.										•			
Ungaromys dehmi					•					•			
Ungaromys nanus				•									
Villanya cf. *exilis*										•			
Lagomorpha													
Hypolagus beremendensis							•						•
Hypolagus brachygnathus				•		•							
Ochotona sp.							•						
Oryctolagus lacosti			•										
Oryctolagus cf. *lacosti*											•	•	
Oryctolagus sp.	•												
Prolagus sp.											•		
Prolagus calpensis	•										•		
Prolagus italicus								•	•				

References 1: Agusti et al., 2010; 2: Agusti et al., 2010; Agusti et al., 2013; 3: Guerin et al., 2004; Sen, 2004; Suarez and Mein, 2004; 4: van den Hoek Ostende and de Vos, 2006; 5: Carls and Rabeder, 1988; 6: Kowalsky, 1958; Rzebik-Kowalska, 2009; 7: Janossy and van der Meulen, 1975 Janossy, 1986; 8: in this paper; Bellucci et al., 2014; 9: Fondi, 1972; Maul et al., 1998; 10: Sala et al., 1994; 11: Girotti et al., 2003; 12: Marcolini, 2003; 13: Marchetti et al., 2000.

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