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THE FIRST RECORD OF THE BIRCH MOUSE *SICISTA* IN THE UPPER PLEISTOCENE SEDIMENTS OF CAVERNA GENEROSA (COMO, NW ITALY), WITH MORPHOMETRICAL, MORPHOLOGICAL AND ECOLOGICAL CONSIDERATIONS

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Key words: *Sicista*, Paleoenvironment, Upper Pleistocene, Northern Italy.

Abstract. In this study a single specimen of a species of the genus *Sicista,* collected from the Caverna Generosa, is described: a right mandible with first molar and m/2-m/3 alveoli. The specimen shows a morphological and morphometrical similarity to *Sicista subtilis* and it may represent the first record in Italy and the third in the whole Europe of this species. The discovery defines advancement in the distribution of *Sicista* in northern Italy and it certainly demonstrates that an important faunal migration took place during the Last Glacial Maximum in the western part of the Po valley.

INTRODUCTION

The main purpose of this work is to present a new Italian discovery of the birch mouse *Sicista* cf. *subtilis* Pallas, 1773. The finding comes from the upper Pleistocene deposits of the Caverna Generosa (in the text also CG), a typical "cave bear" exploited during the last twenty years (Bona 2003, 2004, 2005a, 2005b, 2006; Bona et al. 2007, 2009). Therefore our objective is to contribute to the improvement of the knowledge of climatic and ecological changes that occurred in the western Prealps during the time interval between 50000 y BP to the Holocene. In this paper we present recent data based on a new stratigraphical sequence from the "Saletta", where the excavation, that is still in progress, started in 2009.

Fossil record and current distribution of the genus *Sicista* in Eurasia

Nowadays, the genus *Sicista* (Rodentia; Dipodidae) comprises 13 species that are widespread in northern Eurasia, among which only two of them are present in Europe since the Middle Pleistocene: the southern birch mouse, *Sicista subtilis* Pallas, 1773 - which is a very rare species - and the northern birch mouse, *Sicista betulina* Pallas, 1779 (synonymous *Sicista montana*) (Rofes et al. 2012).

Among the family Dipodidae we distinguish two main subfamily groups: the birch mice Sicistinae (Eurasia) and the jumping mice Zapodinae (New World). The earliest forms of birch mice appear as early as the Oligocene in Europe and Asia (Kurtén 1968; Zhang et al. 2012). Sicistinae spread also in North America during the Late Miocene, including the extant genus *Sicista*, but the latter disappeared in North America before the Quaternary (Zhang et al. 2012).

The first occurrence of *Sicista*, referred to *Sicista primus* Kimura, 2010, has been reported from Gashunyinadege in central Nei Mongol, China (late Early Miocene) (Kimura 2010). Considering this record, the birch mouse is one of the seven extant genera of rodents (a fast-evolving group comprising 468 total genera) appeared during the Early Miocene without significant morphologically changes (Kimura 2010). The origin of *Sicista* is therefore to be brought back to central Asia, wherefrom its early dispersal began both towards North America and Europe.

Sicista fossils found in Europe in the early Pleistocene are: *Sicista* sp. from Romania and Ukraine (these findings are the oldest record of Pleistocene), *S. praeloriger* from Les Valerots in France (westernmost limit for the genus in this period) (Rofes et al. 2012) and *S. subtilis* from Temnata cave in Bulgaria (southernmost extension of the genus) (Kowalski 2001).

During the Middle Pleistocene *S. praeloriger* restricted its range to central Europe. On the other hand, *S. subtilis* spread through Europe reaching

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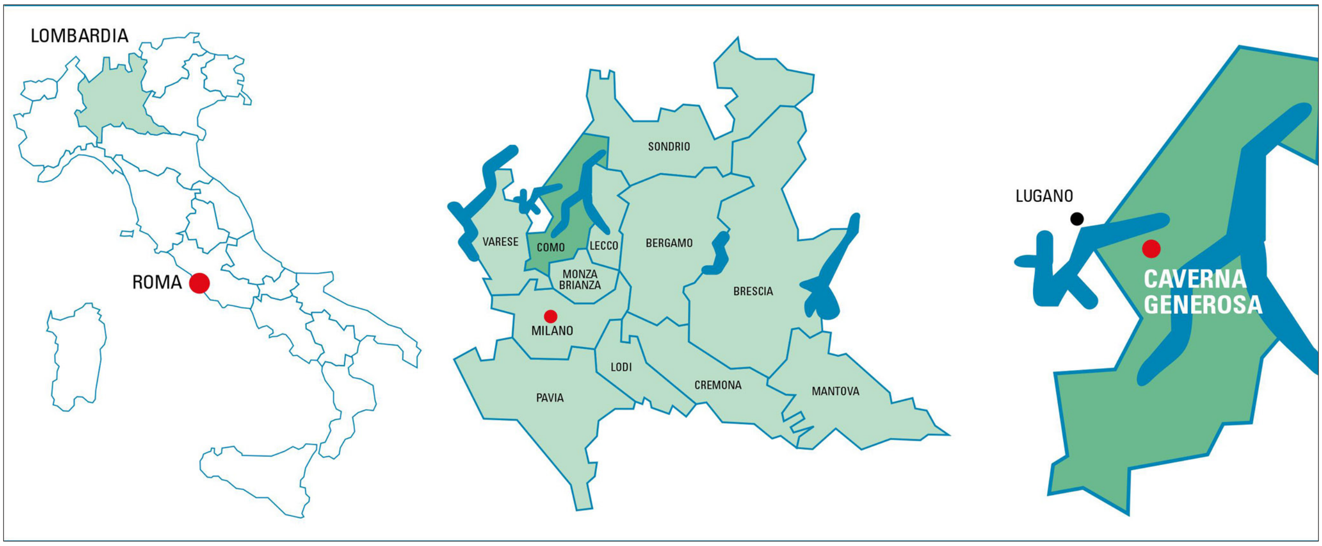

Fig. 1 - Geographical position of Caverna Generosa (Lo Co 2694).

the Netherlands to the North and Greece to the South. Other remains assigned to *Sicista* sp. were recovered from United Kingdom, representing the northernmost record for the genus in the Middle Pleistocene. In this time interval, the new species *S. betulina* appeared, mainly restricted to Western Europe, especially in France with a few record in Germany, Hungary and Romania (Rofes et al. 2012 and references therein).

During the Late Pleistocene the last specimen of *S. praeloriger* was found in the Czech Republic, before the extinction of the species (Rofes et al. 2012). The distribution of *S. subtilis* slightly spread westernward to Gigny, France (Chaline et al. 1995), whilst *S. betulina* stretched across Europe, reaching northern Spain (Rofes et al. 2012), northern Switzerland (Oppliger & Becker 2010) and Italy (Bartolomei 1966; Pasa 1953; Bon et al. 1991; Berto & Rubinato 2013). During the most temperate interval of the Holocene, the steppe-like areas of Europe reduced and the distribution of the birch mice concurrently shrank, especially in the eastern part of the continent. In fact, the current range of *S. subtilis* in western Europe comprises only some isolated populations in Hungary, Romania, Bulgaria and South Poland (Kryštufek et al. 2008), whereas *S. betulina* reaches the western part of Europe: Scandinavia, Switzerland, Germany, Austria and Hungary (Meinig et al. 2008). *S. subtilis* inhabits open landscape as steppe, preferring hilly and mountainous areas, and extends into semi-desert areas, tending to prefer open habitats (Kurtén 1968; Kryštufek et al. 2008). In contrast, *S. betulina* is mainly located in birch and pine/fir forests of taiga with dense ground vegetation (Meinig et al. 2008).

Occurrence of *Sicista* in Italy

During the Late Pleistocene, *Sicista* was very rare in Italy as testified by the presence of just a few remains. The first occurrence of the genus *Sicista* in Italy is reported in the early Late Pleistocene at the Mezzena rock-shelter, with remains ascribed to *Sicista montana* (=*Sicista betulina*) and *Sicista* sp. (Bon et al. 1991) and at Fumane cave (*Sicista betulina*) (Lopez-Garcia et al. 2015), both located near Verona. The subsequent records, with specimens attributed to *S. betulina* or *Sicista* sp., come from Broion cave and Grotta di Paina (Vicenza; Bartolomei et al. 1988), Ponte di Veja Cave A, Tagliente shelter [originally identified as *Sicista* sp. (Bon et al. 1991); however Berto (2013) argues that the attribution of this fossil to *Sicista* was a mistake], Averla cave (Verona; Pasa 1953; Bon et al 1991), Caverna degli Orsi cave (Trieste province; Berto and Rubinato 2013) and Grotte Verdi di Pradis (Pordenone; Bartolomei et al. 1984). In western Italy the birch mouse was reported from Arma delle Manie (Savona; Abassi 1999). In central Italy, *Sicista* was collected at Ferrovia Cave (Ancona; Bartolomei 1966), being the southernmost record in Europe. All these sites have been dated as Late Pleistocene before the Tardiglacial (MIS 3 and MIS2).

THE CAVERNA GENEROSA: GEOGRAPHICAL SETTING, STRATIGRAPHY AND AGE OF THE "SALETTA" DEPOSIT

The Caverna Generosa is located in the north-western Lombardian Prealps, at 1450 m a.s.l. on the Italian side of Monte Generoso (maximum elevation 1701 m a.s.l.), near the border with Switzerland (Fig. 1).

The CG is about 200 meters long but Upper Pleistocene deposits with faunal remains occur in the first 80 meters. In this area three main subdivisions are recognizable: an initial narrow passage called "Cunicolo", a little "room" called "Saletta" and the biggest "room" called "Sala Terminale" connected to the former "Saletta" through a gallery called "Sifone", a narrow syphon shaped passage (Fig. 2).

The data here presented come from a new stratigraphical sequence in the little "room" "Saletta", where the excavation, that is still in progress, started in 2009.

The uppermost six units of the "Sala Terminale" have been dated between 50000 and 38000 y BP using the 14C method (Fig. 2). The age of the units below exceeds the limits of the 14C dating method, but it is probably around 60000 y BP (Bona et al. 2007).

In the "Cunicolo13-15" the units from II to V have been dated between 37000 and 31000 y BP (Bona et al. 2009).

The new stratigraphical sequence of "Saletta", composed of 9 stratigraphical levels, lack 14C datings. However, the recovered faunal assemblages allow to correlate the "Saletta" sequence to both the "Sala Terminale" and "Cunicolo". In particular, unit 5a is correlable to units 4 to 2 of "Sala Terminale" and to unit CUN IV of "Cunicolo" (Fig. 2). Units 3 to 2 of "Saletta" are correlable to CUN III and II of "Cunicolo". A gap in sedimentation occurs below the base of unit 1 of "Saletta", which is correlable to CUN 0 of "Cunicolo". Therefore, the "Saletta" sequence probably covers the interval between 45000-40000 y BP to the Holocene (Savoldi 2011).

MATERIALS AND METHODS

A right hemi-mandible of a birch mouse, coming from unit 3 of the "Saletta", is the most important remain here described (number: MG Saletta 1084).

The sediments, removed from the "Saletta" in the CG, had been sieved with a 1 mm mesh sieve and then they had been picked to collect micro-vertebrates remains. The paleoenvironmental analysis presented in this study is based on 1472 remains of small mammals.

To establish the MNI (Minimal Number of Individuals) and the relative frequencies the more represented skeleton portion had been used. The most frequent bone of the voles is often the first lower molar. These counts had been estimated considering also: 1) the siding of the same bones (for example: 3 left humerus and 2 right humerus mean the presence of at least 3 individuals); 2) the stratigraphical position of the bone; 3) the ontogenetic stages (for example the development of rooted teeth of *Clethrionomys glareolus* or the dental wear of *Apodemus* spp. teeth are different in juveniles, sub-adults and adults).

The remains of microvertebrates have been divided according to their skeletal elements through a binocular microscope 'Wild Heerbrugg M3' with a magnification from 6,4 x to 40 x. Afterwards, the small mammal specimens have been identified following Chaline et al. (1974) and Niethammer and Krapp (1978; 1982; 1990). The taxonomic identification of the chiropters has been based on the diagnostic characters reported by Dodelin (2001) and Menu and Popelard (1987).

PALEOENVIRONMENTAL REMARKS

Small mammal remains consist of 1472 specimens belonging to 20 different taxa and covers a time span of about 40000 y, the interval between MIS3 and the Holocene.

The paleoenvironmental analysis of the "Saletta" sequence is based on faunal associations, considering the ecology of the species, that occurred in each unit (Tab. 1).

Unit 6 - Due to the scarcity of remains (only four specimens discovered) it is not possible to reach a conclusion on the paleoclimate and paleoenvironment at present. However, it is interesting to remark the presence of one first lower molar of *Clethrionomys glareolus* (Schreber, 1790); this species is not very common in the cave. One specimen of *Arvicola amphibius* Linnaeus, 1758 and of *Chionomys nivalis* (Martins, 1842) have been also collected.

Unit 5 - This level is characterized by the presence of *Microtus* (*Terricola*) gr. *T. multiplex* (Fatio, 1905)-*subterraneus* (Selys-Longchamps, 1836) (19.1% of MNI), *Chionomys nivalis* (10.6% of MNI) and *Microtus* gr *M. arvalis* Pallas, 1778-*agrestis* Linnaeus, 1761 (31.9% of MNI). The significant occurrence of *Chionomys nivalis* and *Microtus arvalis*, related to scarcity of taxa linked to forested areas, proves that during the deposition of unit 5 Monte Generoso was characterized by open areas with exposed rocks and reduced forested spaces. However, the abundant occurrence of *Arvicola amphibius*

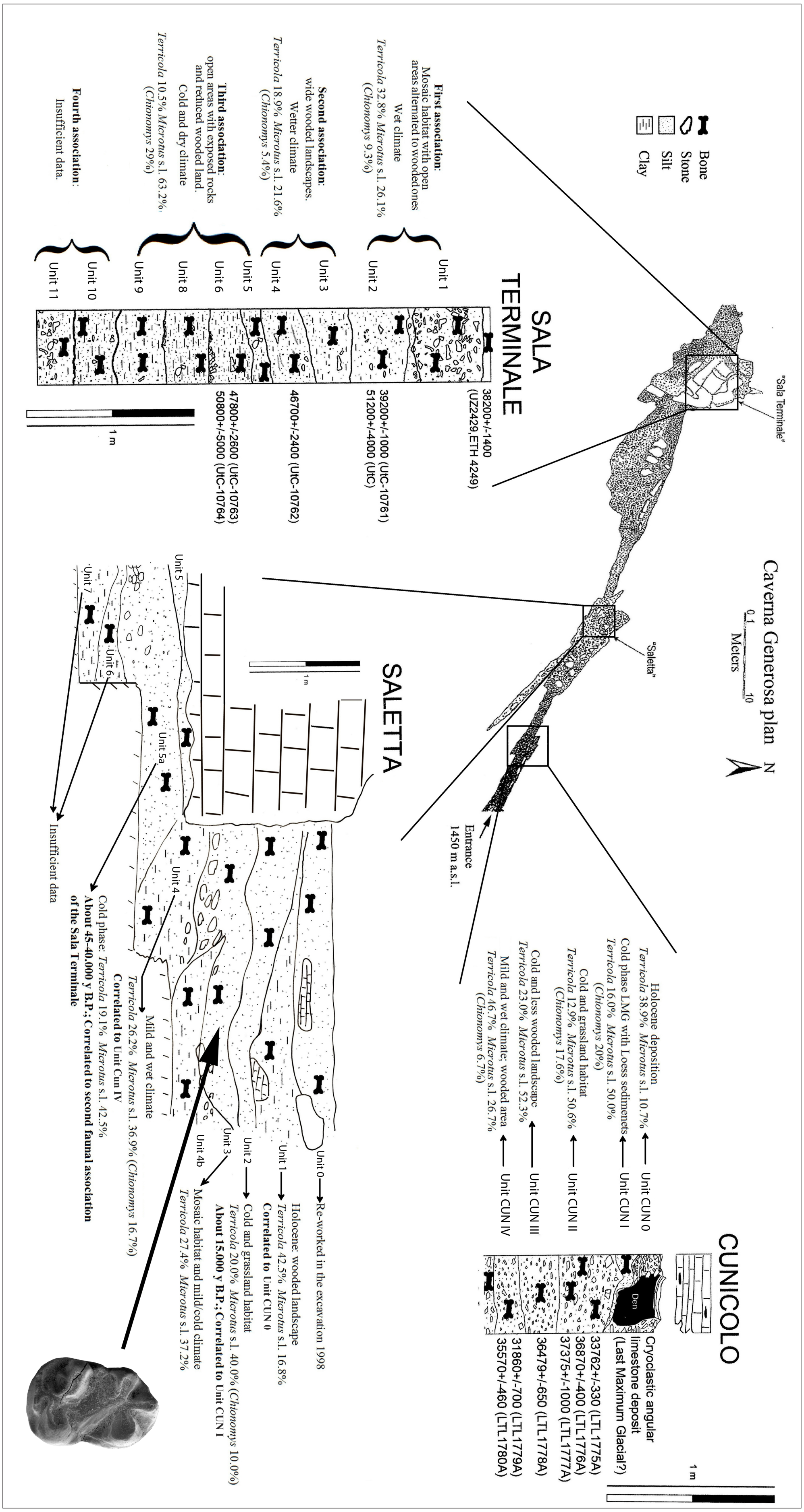

Fig. 2 - Comparison and correlation of the three principal stratigraphical sequences of Caverna Generosa: "Sala Terminale", "Saletta" and "Cunicolo". Data from "Sala Terminale" and "Cunicolo" from Bona et al. (2007, 2009).

"SALETTA" Units	**0**		**1**		**2**		**3**		**4**		**5**		**6**		**TOTAL**	**TOTAL**
	MNI	**%**	**MNI**	**%**	**MNI**	**%**	**MNI**	**%**	**MNI**	**%**	**MNI**	**%**	**MNI**	**%**	**MNI**	**REMAINS**
TAXON																
RODENTIA																
Microtus (Terricola) gr. *M. (T.) multipl.-subter.*	**15**	24.6	**48**	42.5	**12**	20.0	**31**	27.4	**22**	26.2	**9**	19.1			**137**	**278**
Microtus (Terricola) savii			**2**	1.8											**2**	**2**
Clethrionomys glareolus	**1**	1.6	**8**	7.1			**1**	0.9					**1**	25.0	**11**	**26**
Microtus arvalis	**10**	16.4	**8**	7.1	**10**	16.7	**15**	13.3	**10**	11.9	**11**	23.4			**64**	**126**
Microtus gr. *arvalis - agrestis*			**1**	0.9	**2**	3.3	**4**	3.5	**2**	2.4	**1**	2.1			**10**	**20**
Microtus sp.			**1**	0.9	**4**	6.7	**2**	1.8	**5**	6.0					**12**	**16**
Microtus agrestis	**3**	4.9	**2**	1.8	**6**	10.0	**8**	7.1	**5**	6.0	**3**	6.4			**27**	**45**
Chionomys nivalis	**12**	19.7	**8**	7.1	**6**	10.0	**15**	13.3	**14**	16.7	**5**	10.6	**1**	25.0	**61**	**103**
Arvicola amphibius	**10**	16.4	**5**	4.4	**9**	15.0	**20**	17.7	**21**	25.0	**12**	25.5	**2**	50.0	**79**	**600**
Apodemus gr. *A. sylvaticus-flavicollis*	**3**	4.9	**9**	8.0	**1**	1.7	**1**	0.9							**14**	**36**
Sicista cf. *subtilis*							**1**	0.9							**1**	**1**
Glis glis	**1**	1.6	**2**	1.8											**3**	**26**
Eliomys quercinus			**1**	0.9											**1**	**1**
EULIPOTYPHLA																
Talpa caeca	**3**	4.9	**6**	5.3	**3**	5.0	**4**	3,5	**2**	2.4	**3**	6.4			**21**	**91**
Talpa europaea	**1**	1.6	**3**	2.7	**1**	1.7	**4**	3,5	**1**	1.2	**1**	2.1			**11**	**51**
Sorex araneus	**1**	1.6	**3**	2.7	**2**	3.3	**3**	2,7	**1**	1.2	**1**	2.1			**11**	**21**
Sorex minutus					**1**	1.7			**1**	1.2	**1**	2.1			**3**	**3**
Sorex sp.	**1**	1.6	**1**	0.9			**1**	0.9							**3**	**5**
Crocidura suaveolens					**1**	1.7	**1**	0.9							**2**	**2**
CHIROPTERA																
Plecotus auritus					**1**	1.7									**1**	**1**
Plecotus sp.			**1**	0.9											**1**	**1**
Myotis vel *Plecotus*							**1**	0.9							**1**	**1**
Myotis nattereri vel *M. emarginatus*							**1**	0.9							**1**	**1**
Myotis bechsteinii			**1**	0.9											**1**	**1**
Myotis emarginatus			**1**	0.9	**1**	1.7									**2**	**2**
Rhinolophus hipposideros			**1**	0.9											**1**	**1**
Chiroptera indet.			**1**	0.9											**1**	**1**
TOTAL MNI	**61**		**113**		**60**		**113**		**84**		**47**		**4**		**482**	**1462**

Tab. 1 - List of the taxa found from each unit of "Saletta" series: Minimum Number of Individuals (MNI) and its percentage (%).

(25.5% of MNI), who lives near fresh water bodies like rivers and lakes, confirms the presence of wet environments. Therefore the paleo-climate chracterizing this time interval should have been cold and wet.

Unit 4 - The frequency of *Microtus* (*Terricola*) gr. *T. multiplex-subterraneus* increases to 26.2% of MNI, but the majority of the remains belongs to *Microtus* gr. *M. arvalis-agrestis* (20.2% of MNI) and *Chionomys nivalis* (16.7% of MNI), whose frequency attained here is the maximum in the whole succession. This unit probably represents a mild and wet phase of MIS 3 interstadial. In fact, species linked to wet areas are still present but their frequencies lightly decrease: *Arvicola amphibious* (25% of MNI) and Eulipotyphla (6% of MNI).

Unit 3 - It is certainly the most interesting unit of this series because of the presence of *Sicista* and the largest number of classified finds: 332 remains for 113 MNI.

The paleoenvironment does not seem to have significantly changed from the previous unit. In fact, *Microtus* gr. *M. arvalis-agrestis* (23.9% of MNI) is still frequent and it is accompanied to *Chionomys nivalis* (13.3% of MNI), while the frequency of taxa linked to forested areas increases lightly: *Microtus* (*Terricola*) gr. *T. multiplex-subterraneus* (27.4% of MNI), *Clethrionomys glareolus* (0.9% of MNI) and chiropters (1.8% of MNI).

It is interesting to note a decreasing frequency of *Arvicola amphibius* (17.7% of MNI), a species that lives in wet environments. On the contrary, *Sicista* is a typical continental steppe/birch forest dweller.

Therefore this assemblage suggests climate conditions comparable to the final stages of MIS 3 or the beginning of the MIS 2.

Unit 2 - The content in small mammals of this unit consists of 60 individuals (MNI) belonging to 13 taxa.

Typical species of cold climate and open landscape became dominant in the faunal association: *Microtus* gr. *M. arvalis-agrestis* (30% of MNI) and *Chionomys nivalis* (10% of MNI). Moreover the presence of *Microtus* (*Terricola*) gr. *T. multiplex-subterraneus* (20% of MNI), *Apodemus* gr. *A. sylvaticus* Linnaeus, 1758-*flavicollis* Melchior, 1834 (1.7% of MNI) and of the chiropters *Plecotus auritus* Linnaeus, 1758 (1.7% of MNI) and *Myotis emarginatus* Geoffroy, 1806 (1.7% of MNI) testifies to the occurrence of covered areas. It is important to note the presence of *Sorex minutus* Linnaeus, 1766 and *Crocidura suaveolens* Pallas, 1811. Among the family Soricidae, the

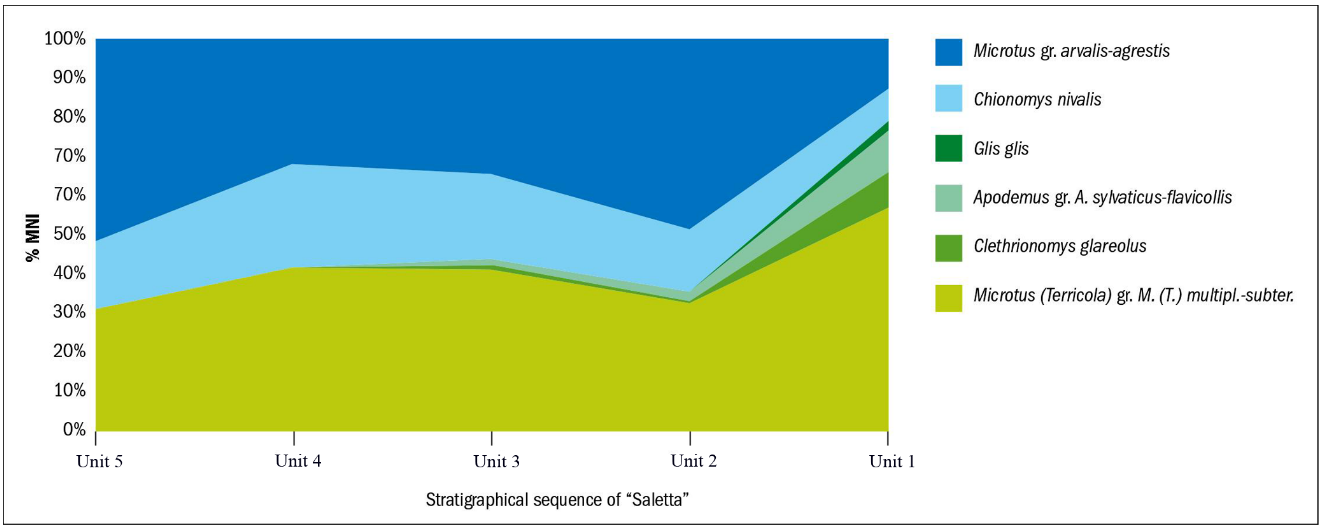

Fig. 3 - Variation of the "Bush" taxa (*Terricola, Clethrionomys, Glis* and *Apodemus*) versus "Praire" taxa (*Microtus* and *Chionomys*) along the "Saletta" stratigraphical succession.

genus *Crocidura* is the most adapted to dry and open environment (Chaline et al. 1974).

Wet areas are still widely recorded present and this is testified by the occurrence of Soricinae (5% of MNI) and *Arvicola amphibius* (15%).

This assemblage is indicative of climate cooling and environmental deterioration, and - given that this unit is correlable to CUN I - suggests deposition during MIS 2, shortly before the Last Glacial Maximum (LGM).

The LGM in the Monte Generoso area may be characterized by the presence of open spaces that alternate with small wooded ones and aquatic habitats, proving that glaciers have not ever covered this area (Bini & Cappa 1975).

Unit 1 - In this unit 113 individuals (MNI) have been indentified as belonging to 19 taxa of small mammals. The faunal assemblage is Holocene in age and it is clearly characterized by a great abundance of the wooded taxa. In fact, the most frequent species is *Microtus* (*Terricola*) gr. *T. multiplex-subterraneus* with the 42.5% of MNI, followed by *Clethrionomys glareolus* (7.1% of MNI), *Glis glis* Linnaeus, 1766 (1.8% of MNI) and *Apodemus* gr. *A. sylvaticus-flavicollis* (8% of MNI). The latter is considered mainly typical of woodland, hedgerows and field margin, orchards and wooded gardens (Macdonald & Barret 1993). The frequency of *Chionomys nivalis* (7.1% of MNI) and *Microtus* gr. *M. arvalis-agrestis* (9.7% of MNI) decreases steeply. The climate probably turned milder and the landscape became more wooded.

The presence of the following species is very important and just one individual has been determined for each of them: *Eliomys quercinus* Linnaeus, 1766, *Plecotus* sp., *Myotis emarginatus, Myotis bechstenii* (Kuhl, 1817) and *Rhinolophus hipposideros* (Bechstein, 1800). All the previously described species are typical of wooded areas with dense underbrush (Blant et al. 2004). The presence of *Eliomys quercinus* is significant, as it represents the first and unique remain.

It is interesting to observe a severe reduction of humid habitats testified by *Arvicola amphibius*, which is present with only 4.4% of MNI.

Thus the "Saletta" sequence starts recording a cold phase testified by unit 5 (Figs 2 and 3). Then the situation changes and becomes slightly more temperate and wooded. This is followed by a shift toward more temperate conditions accompanied by the development of wooded areas. A climate deterioration is then recorded by unit 2, characterized by the dominance of cold and grassland species; this is interpreted to correspond to part of MIS 2. However, a gap in sedimentation at the top of this unit does not allow to trace the LGM and Tardiglacial.

SYSTEMATIC PALEONTOLOGY

Order **Rodentia** Bowdich, 1821
Family Dipodidae Fischer de Waldheim, 1817
Subfamily Sicistinae Allen, 1901
Genus *Sicista* Gray, 1827

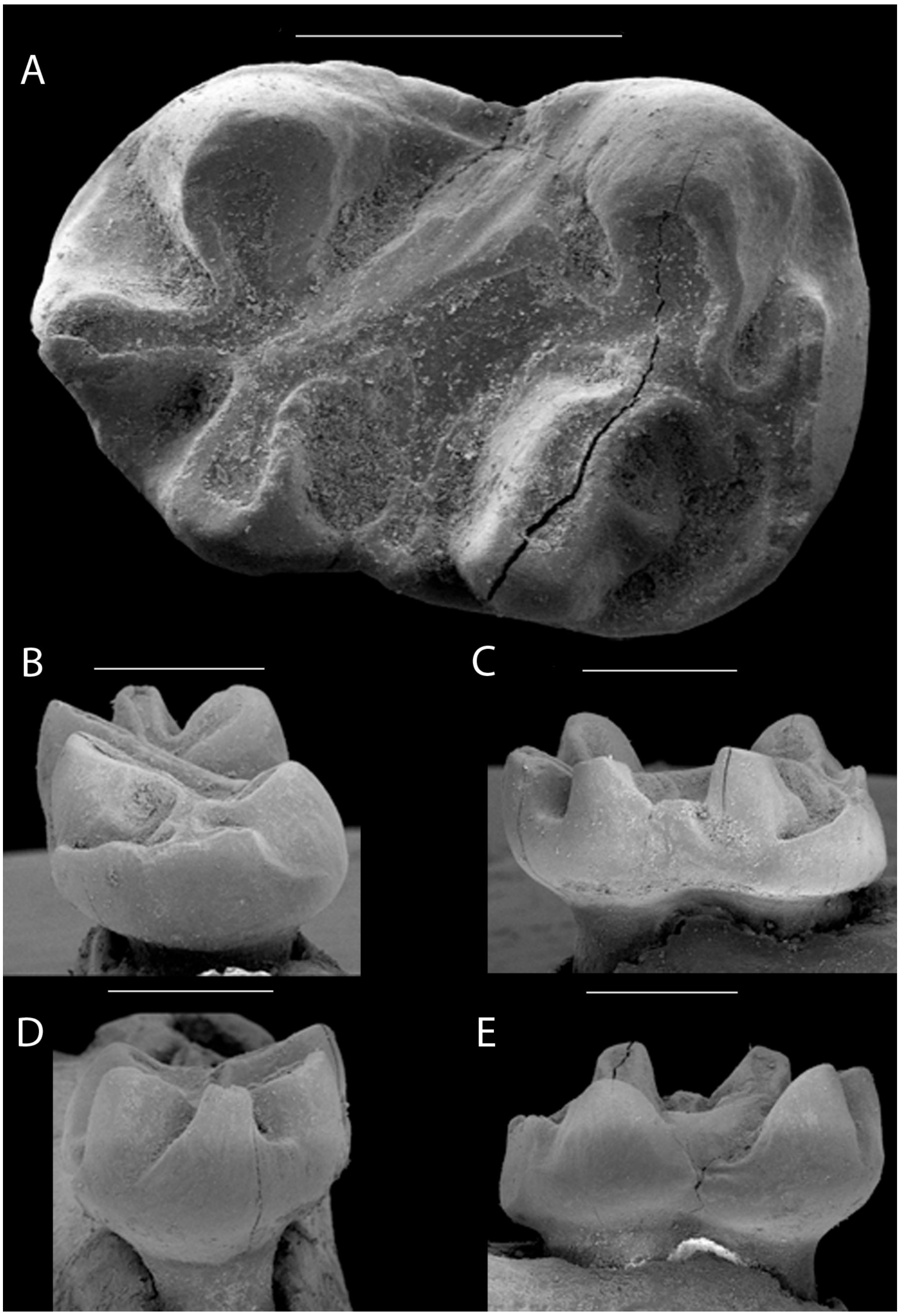

Fig. 4 - *Sicista* cf. *subtilis* (MG Saletta 1084) m/1. A) Occlusal surface; B) distal view; C) lingual view; D) mesial view; E) buccal view.
Scale bars: 500 µm.

Sicista cf. *subtilis*

Remarks. The fossil remain referred to *Sicista* cf. *subtilis* is a right hemi-mandible with first molar and m/2-m/3 alveoli containing fragments of roots.

The *Sicista* hemi-mandible from CG was found in 2012 during the sieving of the sediments coming from unit 3 of the "Saletta" stratigraphical succession.

The small mammal fauna belonging to the same unit is characterized by species that testify the presence of a mosaic habitat dominated by open landscape with exposed rock substrate, woodland and bushy and wet areas.

Morphology and morphometry

Morphology. The m/1 is well preserved. The wearing degree of the tooth is low. The occlusal outline is convergent mesially to the labial side and shows a prominent protoconid. This tooth presents five well-developed principal cusps, even if hypoconid and protoconid are slightly higher. The mesolophid is faintly shown and slightly visible; it does not reach the labial margin of the tooth. The posteroloph is low and well extended. There is not

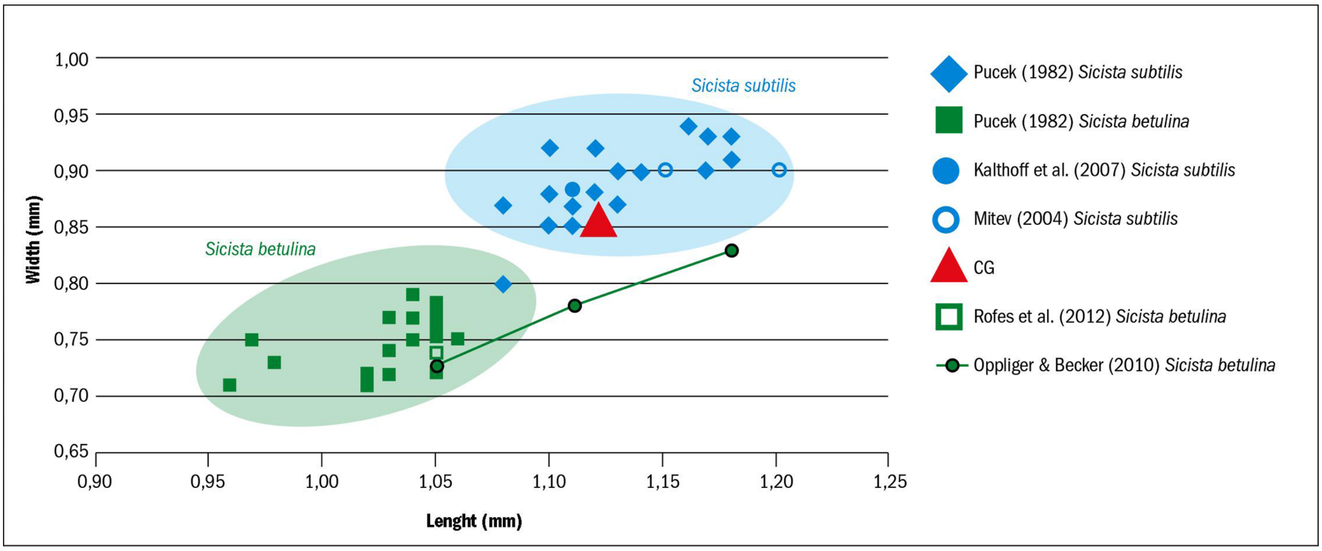

Fig. 5 - Comparison between the size of m/1 of two species of *Sicista*: *S. betulina* and *S. subtilis*. In the graph data from CG and other fossil specimens are included along with also currently *Sicista* material. Oppliger and Becker (2010) do not report any measures of the 17 m/1 found in Vâ Tche Tchâ population (north-western Switzerland), so inside the graph we draw a segment that combines the maximum, the medium and the minimum value, given by the authors themselves.

additional cusp in the tooth (Fig. 4).

Compared to *S. subtilis*, the typical morphology of *S. betulina* teeth is generally characterized by a more complicate dental structure. Oppliger and Becker (2010) highlight as the teeth of *S. betulina* reveal more complex crown morphology than that of *S. subtilis*, and this complexity always characterizes the talonid of the lower molar. But it is important to remember that the detection of the whole dental morphology is not always feasible, especially additional cusps, because they are dependent by the state of preservation and the wearing of teeth. In a morphological comparison between the two *Sicista* species it is possible to make a successful distinction from a statistical point of view, if the data set is large enough. In fact, of the characters described by Oppliger & Becker (2010) for *Sicista betulina,* some are also present in *S. subtilis*. In the Quaternary deposits of Vâ Tche Tchâ, in north-western Switzerland one hundred isolated teeth of *Sicista betulina* have been found (Oppliger & Becker 2010), and among them 17 first lower molars. The authors highlight some features on these lower first molars: I) presence of an additional cusp between the entoconid and the posteroloph (13 specimens out of 17), in any case this cusp is present in the mesial part of the entoconid (5 out of 17); II) all the m/1 display a small concavity between the hypoconid and the protoconid; III) the hypoconid is slightly prominent in 13 specimens out of 17; IV) in 12 m/1 the mesolophid is well developed.

No one of these characters has been observed in the CG specimen and for this reason it is possible to demonstrate its greater affinity to *S. subtilis* (Fig. 4).

Kalthoff et al. (2007) suggested another morphological character to discriminate the two European birch mouse species. The occlusal outline (at the labial side) of *S. subtilis* m/1 converges anteriorly, showing a more prominent protoconid and giving it a general shape much less rounded and oval than *S. betulina* (Kalthoff et al. 2007: Fig 5). This results in a deeper concavity between hypoconid and protoconid, that is not present in *S. betulina*. Based on Kalthoff et al. (2007) discussion, the CG specimen shows a higher similarity to *S. subtilis*.

Morphometry. Dimensions of m/1 (mm): length = 1.12; width = 0.86.

As shown above, it is really hard to distinguish between the two Pleistocene European birch mouse species, only based on to the teeth morphology.

For the extant species this problem can be solved by considering the different dimensional ranges of the two species (Niethammer & Krapp 1982; Kalthoff et al. 2007; Oppliger & Becker 2010). In fact, in modern species the teeth of *S. subtilis* are, on average, larger than those of *S. betulina*. It is hard to apply the same criterion to distinguish the Pleistocene representatives, because, as observed in the populations of *Sicista betulina* of Vâ Tche Tchâ, during this period *S. betulina* m/1 increased its size overlapping that of *S. subtilis*; however, the latter shows a greater width. Moreover, we can point out that the dental size of the specimens of species of *Sicista*, like other rodents, shows a great variability due to different factors as environment, climate, competition and predation (Pucek 1982). The sizes of the CG specimen fall within the range of variation of the present Romanian *S. subtilis* reported by Pucek (in Niethammer and Krapp 1982: 501-515) and about the group of *S. betulina* described by the same author. Furthermore, the CG remain is larger than the single remain of *S. betulina* from Lezetxiki cave (MIS 5, Northern Spain) (Rofes et al. 2012) and closer to the size of the coeval *S. subtilis* from Wannenköpfe volcanoes (MIS 3, western Germany) (Kalthoff et al. 2007). It is also comparable to the minimum size of *S. subtilis* reported by Mitev (2004) and coming from the Holocene of Bulgary. However, the CG remain is smaller than the single Holocene specimen of *S. subtilis* reported by Chaline (1972) from France. Comparing the CG specimens of *Sicista* to the population of *S. betulina* from Switzerland (Oppliger & Becker 2010) and to the coeval population of *S. betulina* from France (Chaline 1972), they seem to have a slightly greater width. The CG remain is larger than the single tooth of *S. betulina* discovered in the coeval Broion Cave (Zanalda 1995).

Fig. 5 clearly highlights the dimensional differences between the two species of *Sicista*: *S. betulina* is considerably smaller than *S. subtilis*. It also shows how the size of the m/1 of the CG *Sicista* specimens falls perfectly within the group size of *S. subtilis*.

Therefore, considering the dimensional features of the CG remain, it can be referred to *S. subtilis*. It is also interesting to note that the size of CG remain falls in the lower end of variation of the *S. subtilis* range.

Conclusion

Based on morphology and morphometry, the CG remain here examined shows a greater affinity to *S. subtilis* and it is thus referred to *S.* cf. *subtilis*. However, the analysis being based on a single specimen, we prefer to leave the specific determination open.

The presence of this continental steppe dweller in the Caverna Generosa testifies to a continuum between the cold and the arid phase during the Last Glacial Maximum for the whole Po valley floodplain from the East to the West. In fact, during cold climate oscillations, the Po valley expanded much further to the South due to the sea level fall. This allowed large areas to emerge and connect continental lands from the Dinaric Alps to the Marche Apennines (Sala & Marchetti 2004). This created a passageway for mammals coming from East, such as small mammals rodents *Microtus oeconomus* (Pallas, 1776), *Sicista betulina*, and the large ones pachyderms *Mammuthus primigenius* (Blumenbach, 1799) and *Coelodonta antiquitatis* (Blumenbach, 1799) (Gallini & Sala 2001; Sala & Marchetti 2004). It is also important to underscore that neither the Arctic tundra dwellers such as musk ox, *Ovibos moschatus* (Zimmermann, 1780), nor the steppe saiga antelope, *Saiga tatarica* Linnaeus, 1766, have ever reached Italy despite their wide diffusion in mid-boreal Europe (Sala et al. 1992). The reindeer, *Rangifer tarandus* (Linnaeus, 1758), come from the West to reach only the westernmost portion of Liguria; this cervid was collected at the Balzi Rossi and Grotta dei Fanciulli (Imperia) (Boule 1906; Palma di Cesnola 1983) and at Caverna degli Zerbi and in reworked sediments of the Arma dell'Aquila (Savona) (B. Sala pers. comm.), both recording the LGM.

By considering the first record of *Sicista* cf. *subtilis* hitherto examined, it is possible to conclude that these faunal migrations reached not only some Venetian areas and the southern Marche coming from the North-East, but also the western part of the Po valley, coming from the West

Moreover, if new discoveries in the Caverna Generosa confirm our identification of *Sicista subtilis*, the remains here examined would be the first record in Italy and the third record in the whole of Western Europe, in addition to coeval deposits of Gigny (France) (Chaline et al. 1995) and Wannenköpfe volcanoes (western Germany) (Kalthoff et al. 2007).

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