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Small and large mammals from the Ciota Ciara cave (Borgosesia, Vercelli, Italy): An Isotope Stage 5 assemblage

Les petits et grands mammifères de la grotte Ciota Ciara (Borgosesia, Vercelli, Italie) : un assemblage du stade isotopique 5

Claudio Berto[a,*,b], Davide Bertè[a,c], Elisa Luzi[d,e], Juan Manuel López-García[d,e], Andrea Pereswiet-Soltan[f,g], Marta Arzarello[a,b]

[a] *Università degli Studi di Ferrara, Dipartimento di Studi Umanistici, Sezione di Scienze preistoriche e antropologiche, C.so Ercole I d'Este, 32, 44121 Ferrara, Italy*
[b] *LT TekneHub, via Saragat, 13, 44122 Ferrara, Italy*
[c] *Associazione Culturale 3P, Progetto Preistoria Piemonte, Via Lunga, 38, 10099 San Mauro Torinese, Turin, Italy*
[d] *IPHES, Institut Català de Paleoecologia Humana i Evolució Social, c/Marcel·lí Domingo s/n (Edifici W3), Campus Sescelades, 43007 Tarragona, Spain*
[e] *Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya, 35, 43002 Tarragona, Spain*
[f] *Institute of Systematics and Evolution of Animals of the Polish Academy of Sciences (PAS), Sławkowska, 17, 31-016 Kraków, Poland*
[g] *Club Speleologico Proteo, Viale Riviera Berica, 631, 36-100 Vicenza, Italy*

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ABSTRACT

The Ciota Ciara cave is located within the Monte Fenera karst system (Borgosesia, Vercelli, Italy) at 670 m a.s.l. The cave entrance presents a deposit with Mousterian quartz and flint industry. The faunal remains from Stratigraphic Units 13, 14 and 103 are the subject of this work and are presented here as a whole for the first time. The large mammal assemblage is dominated by *Ursus spelaeus*. In addition, a few remains of carnivores such as *Panthera leo spelaea*, *Panthera pardus*, *Meles meles* have been found together with ungulates such as *Cervus elaphus* and *Rupicapra rupicapra*. The small mammal assemblage is characterized by a high biodiversity, especially in bats, by the dominance of *Clethrionomys glareolus* and by a relatively large number of *Pliomys coronensis*, a species that seems to disappear from the Italian Peninsula at the end of Marine Isotope Stage 5 or during the beginning of MIS 4. The changes in frequency of the small and large mammals between the two S.U. suggest a change from a relatively cold-humid (S.U. 14) to a warmer-still humid climate (S.U. 13). Although no radiometric dates are available yet, the small and large mammal assemblages, the presence of *Pliomys coronensis* and the climate change inferred by the variation of the small mammal frequencies allow us to correlate these two units of the Ciota Ciara cave to a relatively warm moment of Marine Isotope Stage 5.

Mots clés :
Grands mammifères
Petits mammifères

RÉSUMÉ

La grotte Ciota Ciara est située dans le complexe karstique du Monte Fenera (Borgosesia, Vercelli, Italie) à 670 m a.s.l. Les nombreuses campagnes de fouilles ont permis de mettre en évidence des dépôts à industries moustériennes sur quartz et silex à l'entrée de la

* Corresponding author.
E-mail address: claudio.berto@unife.it (C. Berto).

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grotte. Ce travail se base sur l'étude des restes fauniques de ces dépôts, et particulièrement des unités stratigraphiques 13, 14 et 103. Ces unités se caractérisent par la présence d'un large assemblage de grands mammifères dominé par *Ursus spelaeus* et quelques restes de carnivores tels que *Panthera leo spelaea*, *Panthera pardus*, *Meles meles*, ainsi que des ongulés comme *Cervus elaphus* et *Rupicapra rupicapra*. Les assemblages de grands mammifères de la péninsule Italique du stade isotopique 5 sont relativement bien connus, ce qui n'est pas le cas des assemblages à petits mammifères. En effet, seulement quelques sites datés du MIS 5, principalement dans le Sud de la péninsule, ont révélé la présence de quelques espèces de micromammifères. Dans le site de Ciota Ciara, l'assemblage de micromammifères se caractérise par une grande biodiversité, particulièrement chez les chauves-souris, et une dominance de *Clethrionomys glareolus* et un relativement grand nombre de *Pliomys coronensis*, une espèce qui semble disparaître de la péninsule Italique à la fin du stade isotopique 5 ou au début du stade 4. Le changement dans la fréquence de petits et grands mammifères entre les unités stratigraphiques 13 et 14 suggère un passage d'un climat relativement humide (US 14) à un climat humide plus tempéré (US 13). Bien qu'aucune datation radiométrique ne soit encore disponible, les assemblages de macro- et micro-mammifères, la présence de *Pliomys coronensis* et le changement climatique déduit de la variation dans la fréquence de micromammifères permettent de corréler les deux unités stratigraphiques 13 et 14 de Ciota Ciara à un épisode relativement tempéré du stade isotopique 5.

1. Introduction

The records of small and large mammals during Marine Isotope Stage 5 (MIS 5) of the Italian Peninsula are relatively scarce and not well dated. In general, the faunal assemblages during this period often reflect a more temperate climate than the following Isotopic Stages, with species that would disappear or be strongly reduced in frequency during MIS 4 and 3 up to the Bølling–Allerød interstadial.

Among large mammals, MIS 5 is characterized by the occurrence of *Dama dama dama* (Palombo, 2009), a species that, however, already appears in MIS 9 (Gliozzi et al., 1997). The fallow deer lives in temperate climates and disappears in the north-eastern Italian Peninsula during MIS 4 (Mazza, 2006). Another chronologically important species is *Stephanorhinus kirchbergensis*, which occurs mainly in interglacial conditions (Sala et al., 1992). Finally, *Hippopotamus* seems to disappear in Italy during the last phases of MIS 5 (Sala et al., 1992) and *Palaeoloxodon antiquus* during MIS 4 (Palombo, 2009).

Among the small mammals, *Pliomys coronensis* (=*Pliomys lenki*, priority discussed by Terzea, 1983) seems to be a good chronological indicator for Italian Peninsula, because it is relatively widespread during MIS 5 (Bartolomei et al., 1975; Berto, 2013), while it seems to strongly decrease during the MIS 4, taking refuge in particular areas such as the Lessini Mountains (Verona province). Only one specimen of *Pliomys coronensis* is signaled at Fumane Cave, in levels correlated to the MIS 3 (Bartolomei et al., 1992).

The MIS 5 is characterized by the transition from *Arvicola mosbachensis* to *Arvicola amphibius* (Koenigswald von, 1994; Koenigswald von and Kolfschoten van, 1996; Maul et al., 1998). In central and northern Europe, the SDQ (*Schmelzband Differenzierungs Quotient* or enamel thickness differentiation quotient) analysis of *Arvicola* has allowed to distinguish these voles (basing on the enamel thickness) and to recognize a pattern of progressive decrease of this quotient.

In this context, the small and large mammals from Ciota Ciara cave represent one of the most complete examples of MIS 5 mammal assemblage in the Italian Peninsula and contribute to the knowledge of mammal association dynamics during this period.

1.1. The site

The Ciota Ciara cave is located at 670 m a.s.l. in the karst complex of Monte Fenera (Borgosesia, Vercelli, Fig. 1) which stands upon an Ercinic basement of effusive rocks, surmounted by carbonatic and arenithic lithological units of Mesozoic age with angular unconformity (Fantoni and Decarlis, 2005). It is an 80 m-long, still active karst cavity and was investigated several times during the second half of the XXth century (Fedele, 1988, 1974, 1968, among others), and it represents an example of the first human occupation of north-western Italy.

Starting from 2009, the University of Ferrara, in collaboration with the *Soprintendenza per i Beni Archeologici del Piemonte*, has carried out six excavation campaigns that primarily focussed on the three main Stratigraphic Units with faunal remains and lithic assemblage: 13, 14 and 103 (Arnaud et al., 2014; Arzarello et al., 2013, 2012). Stratigraphic Units 13 and 14 have a horizontal disposition and are characterized by a reddish-brown clay-sand matrix with rare and altered centimetre-sized pebbles, more frequent in S.U. 14. The Stratigraphic Units in question extended over the whole investigated area, with the exception of S.U. 103, which has an almost vertical trend and is localized exclusively in an area of about 50 cm^2, probably as a result of water percolation in the area along the rock wall (Fig. 1) (Daffara et al., 2014).

The lithic assemblage is composed of flakes, retouched tools, cores, hammers and debris. The raw materials were exploited using the direct percussion technique with

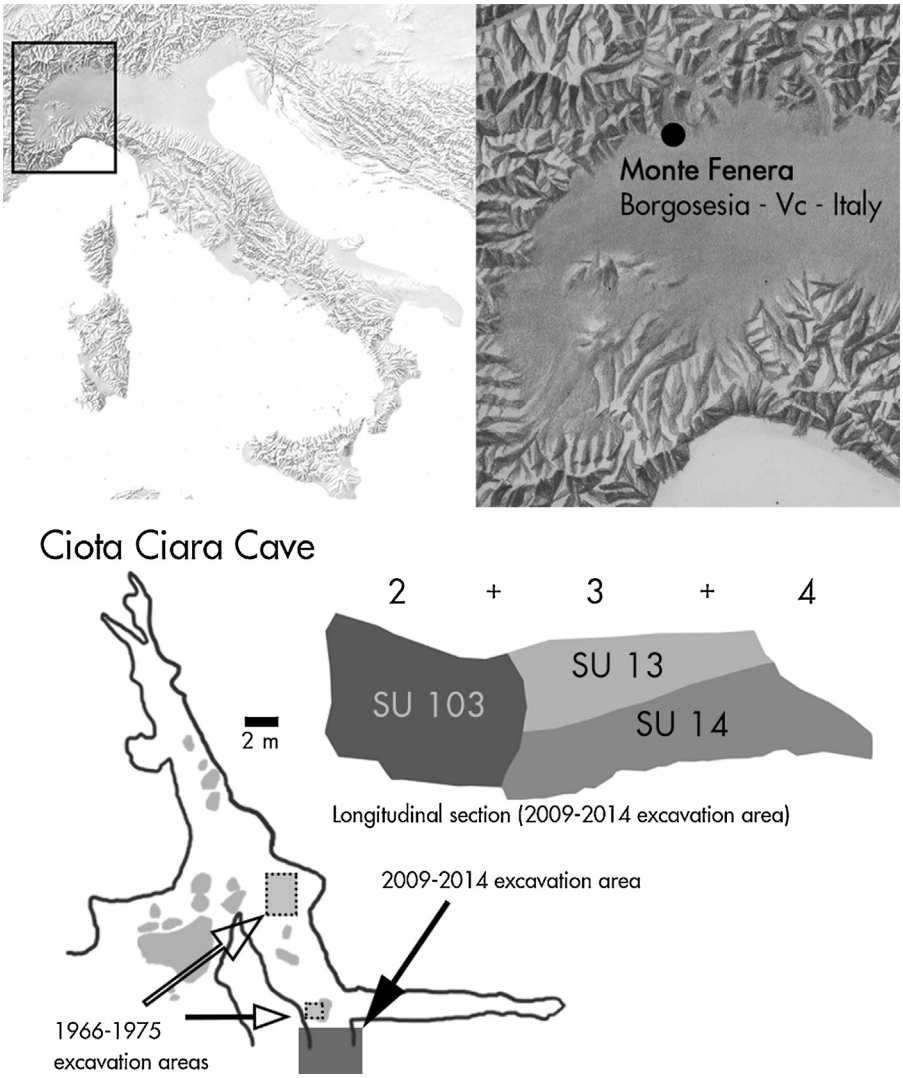

Fig. 1. Location of Ciota Ciara cave (top), simplified stratigraphy of the longitudinal section, cave map and location of excavation areas (bottom).
Fig. 1. Localisation de la grotte Ciota Ciara (en haut), stratigraphie simplifiée de la section longiutudinale, plan de la grotte et zone de fouilles (en bas).

various methods: SSDA (*Système par surface de débitage alterné*, Forestier, 1993), discoid and Levallois (Boëda, 1993, 1988; Daffara et al., 2014). Several lithologies are represented, in different proportions: quartz is the predominantly exploited raw material, followed by spongolite, sandstone, mylonite and opal. The archaeological record consists of various types of quartz: macro-crystalline pegmatite quartz, micro-crystalline pegmatite quartz and hyaline quartz. All these types of raw materials have been found in secondary position in the proximity of the archaeological site, within a 5-km range (Daffara et al., 2014).

The present landscape surrounding the Ciota Ciara cave is characterized by a rich forest dominated by chestnuts, maples and oaks. Among the large mammals, wild boar and roe deer are dominant.

2. Materials and methods

2.1. Large mammals

The large mammal analysis is based on a total of 4904 specimens: 838 from S.U. 13, 120 from S.U. 103 and 3946 from S.U. 14 (Table 1). Forty percent of the specimens was too fragmented for identification. Species determinations were made using the comparative collection from the Large Mammals Laboratory at the Department of Human Studies, University of Ferrara. For each taxon, we calculated the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI). Because the remains of *Ursus spelaeus* had a different mode of accumulation (see par.3.1), this species is considered separately.

Table 1
NISP, MNI and percentages of the NISP for the large mammals from the Ciota Ciara cave.
Tableau 1
NRI, NMI et pourcentages du NRI des grands mammifères de la grotte Ciota Ciara.

	NMI								
	103			13			14		
	MNI	NISP	%NISP	MNI	NISP	%NISP	MNI	NISP	%NISP
Rodents									
Marmota marmota				1	1	0.34	3	68	5.43
Carnivores									
Panthera leo spelaea	1	1	1.89				2	14	1.12
Panthera pardus							1	5	0.40
Lynx lynx				1	1	0.34	1	4	0.32
Canis lupus		1	1.89	1	8	2.74	2	11	0.88
Vulpes vulpes				2	2	0.68	1	3	0.24
Ursus spelaeus	5	33	62.26	9	232	79.45	18	989	78.99
Ursus arctos	1	15	28.30	2	24	8.22	2	17	1.36
Meles meles				1	6	2.05	1	2	0.16
Martes martes							1	1	0.08
Ungulates									
Stephanorhinus sp.							2	4	0.32
Bos primigenius				1	1	0.34	1	1	0.08
Bos vel Bison				1	1	0.34	1	1	0.08
Cervus elaphus				2	8	2.74	5	104	8.31
cf. *Dama*							1	1	0.08
Rupicapra rupicapra	1	3	5.66	2	9	3.08	2	26	2.08
Sus scrofa							1	1	0.08
Total carnivores	7	50	94.34	16	273	93.49	29	1046	83.55
Total ungulates	1	3	5.66	6	19	7	13	138	11.02
Total determined	**8**	**53**		**22**	**292**		**45**	**1252**	
Undetermined		*67*			*546*			*2694*	

Bold is used to highlight the total number of determined sample. NISP: total number of identified specimens by level; MNI: minimum number of individuals by stratum.

2.2. Small mammals

The small mammal remains consist of disarticulated bone fragments collected by water-screening using sieves of 0.5 mm mesh during the excavation campaigns from 2009 to 2013. Part of the material has been previously published in Arnaud et al. (2014) and Arzarello et al. (2012).

The small mammal assemblage comprises a total of 1187 remains, corresponding to a minimum number of 373 individuals (Table 2). The specific attribution of this material was mainly based on the best diagnostic elements: maxilla and isolated teeth for rodents, mandible and maxilla for shrews, mandible, maxilla, isolated teeth and humeri for bats.

The taxonomic classification follows Wilson and Reeder (2005), except *Clethrionomys glareolus* (for the priority over *Myodes*, see Tesakov et al., 2010). Data on the distribution and habitat of the species were taken from Amori et al. (2008), Boitani et al. (2003) and Mitchell-Jones et al. (1999).

We calculated the palaeodiversity using the Simpson index of Evenness = $1-\sum(p_i^2)$, where p_i is the proportion of individuals in the i^{th} species (Harper, 2005; Magurran, 2004). The evenness index is constrained between 0 and 1. The index has been calculated using PAST 3.04 avoiding redundant determinations (i.e., for *Arvicola amphibius*, the individuals determined as *Arvicola* cf. *amphibius* and *Arvicola* sp. were not included in the Simpson index calculation) (Hammer et al., 2001).

The SDQ index (Heinrich, 1978) quantifies the difference in enamel thickness between the anterior and the posterior wall of each triangle of arvicolid molars. This index was calculated for m1 of *Arvicola amphibius* of Ciota Ciara. SDQ was measured for the three main triangles T1, T2 and T3 of first lower molars (SDQ3, according to Kosciow and Nadachowski, 2002; Lippi et al., 1998; Markova, 2005) in order to include the maximum number of specimens. Higher values for these indices generally correspond to early evolutionary stage of *Arvicola*. However, remarkable differences exist between modern populations, and can be correlated to altitude (Kratochvil, 1981) and/or latitude (Maul et al., 1998; Röttger, 1987). Furthermore, critics have been moved to use SDQ as a strong tool for biochronological reconstruction (Escudé et al., 2008). Although this coefficient cannot provide conclusive evidence of the relative age of a fauna, combined with other data – such as the whole composition of the mammal assemblage – SDQ can give additional information about the chronological position of a site (Maul et al., 2000).

2.3. Palaeoenvironment reconstruction based on small mammals

In order to reconstruct the palaeoenvironment at Ciota Ciara cave, we used the method of habitat weighting (Andrews, 2006; Evans et al., 1981), assigning each small mammal taxon to the habitat(s) where it can be found at present in Europe. For this purpose, habitats were divided into six types (Cuenca-Bescós et al., 2009; López-García et al., 2014, 2010): open land with either dry and wet meadows (OD and OH, respectively); woodland environments,

Table 2
NISP, MNI and percentages of the MNI for the small mammals from the Ciota Ciara cave.
Tableau 2
NRI, NMI et pourcentages du NMI de micromammifères de la grotte Ciota Ciara.

	13			14		
	NISP	MNI	% MNI	NISP	MNI	% MNI
Sciurus vulgaris	1	1	2.27	1	1	0.30
Eliomys quercinus				1	1	0.30
Muscardinus avellanarius	2	1	2.27			
Glis glis	3	1	2.27	14	4	1.22
Arvicola sp.				11	3	0.91
Arvicola cf. *amphibius*	6	2	4.55	37	9	2.74
Arvicola amphibius				1	1	0.30
Cricetus cricetus				1	1	0.30
Chionomys nivalis				1	1	0.30
Microtus gr. *arvalis-agrestis*				15	12	3.65
Microtus arvalis	5	3	6.82	101	53	16.11
Microtus agrestis				13	7	2.13
Microtus cf. *gregalis*				7	5	1.52
Microtus (*Terricola*) sp.	3	2	4.55			
Microtus (*Terricola*) gr. *multiplex-subterraneus*				73	44	13.37
Clethrionomys glareolus	56	9	20.45	395	65	19.76
Pliomys coronensis	6	1	2.27	26	7	2.13
Apodemus sp.	2	1	2.27			
Apodemus (*Sylvaemus*) gr. *sylvaticus-flavicollis*	10	5	11.36	26	11	3.34
Erinaceus sp.				3	2	0.61
Crocidura sp.				2	1	0.30
Crocidura suaveolens	1	1	2.27			
Sorex ex gr. *araneus*				2	1	0.30
Talpa sp.	1	1	2.27	12	3	0.91
Talpa cf. *caeca*				5	3	0.91
Talpa caeca	1	1	2.27	30	6	1.82
Talpa cf. *europaea*				4	3	0.91
Talpa europaea	1	1	2.27	1	1	0.30
Rhinolophus sp.				2	1	0.30
Rhinolophus gr. *euryale-mehelyi*				6	3	0.91
Rhinolophus ferrumequinum	3	1	2.27	16	6	1.82
Rhinolophus cf. *hipposideros*				27	9	2.74
Rhinolophus hipposideros				7	5	1.52
Eptesicus conf. *serotinus*				3	2	0.61
cf. *Nyctalus*				6	5	1.52
cf. *Plecotus*				4	2	0.61
Plecotus gr. *auritus-austriacus*				12	2	0.61
Barbastella barbastellus	4	1	2.27	1	1	0.30
Myotis myotis	3	1	2.27	44	8	2.43
Myotis sp.	16	10	22.73	87	21	6.38
Miniopterus schreibersii	3	1	2.27	62	18	5.47
Pipistrellus sp.				1	1	0.30
	127	44		1060	329	

divided into open woodland, woodland margins and forest patches (OW) and woodland and mature forest habitat (W); water, areas along streams, lakes and ponds (Wa); and habitats with a suitable rocky or stony substratum (R) (Table 3).

2.4. Palaeoclimatic reconstruction based on small mammals

In order to infer the palaeoclimatic data from Ciota Ciara cave assemblage, we applied the Mutual Climatic Range method (Elias, 1997; Pross, 2000 among others, see also Blain et al., 2009 and López-García et al., 2014, 2010). This method assesses potential palaeoclimatic conditions by evaluating the current distribution of all taxa occurring in each level.

Two climatic factors were calculated: the mean annual temperature (MAT) and the mean annual precipitation (MAP), using climatic maps of Italy (Attorre et al., 2008) and data provided by the network of Italian meteorological research stations over a period of 30 years. Then, we could compare them with the modern climatic data from the weather station of Borgosesia (359 m a.s.l.). For the area surrounding Ciota Ciara cave, the current data show an MAT = 10.7 °C and MAP = 1009 mm. Because of the scarce interpolations (only two), we also used the linear regression method (Hernández Fernández and Peláez-Campomanes, 2005; Hernández Fernández, 2006, 2004; Hernández Fernández et al., 2007).

The Italian Peninsula is characterized by different climates, due to its peculiar position in the centre of the Mediterranean Sea and its geography. In Italy, two macrobioclimates are present: the temperate bioclimate, which

Table 3
Small mammal distribution by habitat.
Tableau 3
Distribution des micromammifères par habitat.

	OD	OH	OW	W	R	Wa
Sciurus vulgaris				1		
Eliomys quercinus				0.75	0.25	
Muscardinus avellanarius				1		
Glis glis				1		
Arvicola amphibius						1
Cricetus cricetus	1					
Chionomys nivalis					1	
Microtus arvalis	0.75		0.25			
Microtus agrestis		1				
Microtus cf. *gregalis*	1					
Microtus (*Terricola*) gr. *multiplex-subterraneus*			1			
Clethrionomys glareolus			0.25	0.75		
Pliomys coronensis						
Apodemus(*Sylvaemus*) gr. *sylvaticus-flavicollis*				1		
Erinaceus sp.			0.25	0.75		
Crocidura sp.		0.5	0.5			
Crocidura suaveolens		0.5	0.5			
Sorex ex gr. *araneus*		0.75	0.25			
Talpa caeca		0.25	0.5			
Talpa europaea		0.5	0.5			
Rhinolophus gr. *euryale-mehelyi*				0.5	0.25	0.25
Rhinolophus ferrumequinum				0.8	0.2	
Rhinolophus cf. *hipposideros*				0.6	0.2	0.2
Rhinolophus hipposideros				0.6	0.2	0.2
Eptesicus conf. *serotinus*				0.4	0.6	0.1
cf. *Nyctalus*				1		
cf. *Plecotus*	0.2			0.7	0.1	
Plecotus gr. *auritus-austriacus*	0.2			0.7	0.1	
Barbastella barbastellus				0.8	0.2	
Myotis myotis	0.2			0.6	0.2	
Miniopterus schreibersii	0.2	0.2		0.4	0.2	

OD: open dry; OH: open humid; OW: open woodland; Wo: woodland/woodland-edge; Ro: rocky; Wa: water.

is found in the north-eastern Peninsula up to the Marche region, the Po Valley and part of the Appenines as opposed to the Mediterranean bioclimate found in the Tyrrhenian coast up to the Ligurian region and the southern Adriatic coast. These macro-bioclimates are subdivided into nine different climates, and climatic conditions may change abruptly over a few tens of kilometres, from the mildness of the seashore to the harshness of coastal mountain summits (Stoch, 2009).

3. Results

3.1. Large mammals

The faunal assemblage is composed of *Ursus spelaeus*, *Ursus arctos*, *Canis lupus*, *Vulpes vulpes*, *Meles meles*, *Martes martes*, *Lynx lynx*, *Panthera leo*, *Panthera pardus*, *Rupicapra rupicapra*, *Cervus elaphus*, *Bos* sp., *Bos* vel *Bison*, *Sus scrofa*, *Stephanorhinus* sp. and *Marmota marmota*. A right upper incisor previously determined as *Hystrix* sp. from S.U. 13 (Arnaud et al., 2014; Arzarello et al., 2013, 2012; Daffara et al., 2014) has been revised and assigned to *Marmota marmota* (Fig. 2, no. 5).

Ungulates appear to be underrepresented in S.U. 13 and 103 (3,8% of identifiable remains) but in S.U. 14 there is a clear increase (13,4% of determinable remains).

Ursus is the best represented carnivore in the Ciota Ciara cave, and *Ursus spelaeus* is the most copious species in all the stratigraphic units (S.U. 103: 27.50%; S.U. 13: 40,77%; S.U. 14: 59.04%). *Ursus arctos* is progressively rare from the top to the bottom of the sequence: (S.U. 103: 8.33%; S.U. 13: 4.22%; S.U. 14: 1.01%). *Ursus spelaeus* used caves during dormancy and as a nest for the cubs (Pacher and Stuart, 2009), which probably accounts for this species being overrepresented in the assemblage.

The other taxa are represented by only a few remains, but, especially in S.U. 14, the biodiversity is high. The ungulates are more abundant in the lower part of the stratigraphic sequence: in S.U. 103 and 13, the only herbivores present are *Rupicapra rupicapra*, *Cervus elaphus* and a bovid, while in S.U. 14 *Rupicapra rupicapra*, *Cervus elaphus*, cf. *Dama*, *Bos primigenius*, *Bos* vel *Bison*, *Stephanorhinus* sp., and *Sus scrofa* are present. Fedele (1968) also reported the occurrence of *Capra ibex* and *Castor fiber* but they have not been recovered in modern excavations. In a breach of the site of Ara, near Ciota Ciara cave, a mandible of *Stephanorhinus kirchbergensis* has been found (Giacobini and Strobino, 1978), attesting to the presence of this species in the area of Monte Fenera.

Considering the MNI in S.U. 14, the most abundant taxon is *Ursus spelaeus* (18 specimens), followed by *Cervus elaphus* (five specimens) and *Marmota marmota* (three specimens). All the other taxa are represented by only one or two specimens. The deciduous teeth of bear are abundant (71 specimens); unfortunately, cubs of *U. spelaeus* are not distinguishable from *U. arctos*. Considering the

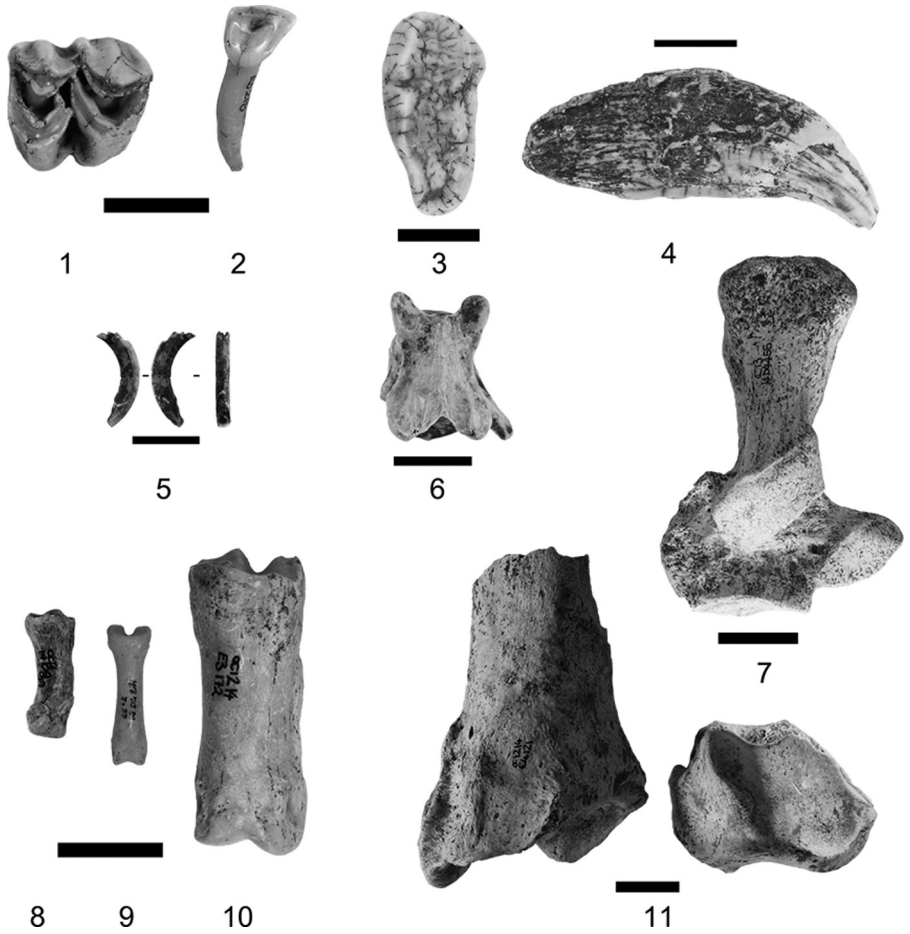

Fig. 2. Some large mammals identified from the Ciota Ciara cave, S.U. 14, all scales are 2 cm long. 1. *Cervus elaphus*, left m2; 2. *Cervus elaphus*, right i3; 3. *Ursus spelaeus*, right M2; 4. *Ursus spelaeus*, right upper C; 5. *Marmota marmota*, right upper I (lingual, labial and occlusal view); 6. *Canis lupus*, third cervical; 7. *Ursus spelaeus*, right calcaneus; 8. *Panthera pardus*, second phalanx; 9. *Vulpes vulpes*, first phalanx; 10. *Cervus elaphus*, first phalanx; 11. *Panthera leo spelaea*, right tibia.

Fig. 2. Quelques exemples de grands mammifères identifiés à Ciota Ciara, U.S. 14 (échelle = 2 cm). *Cervus elaphus*, m2 gauche; 2. *Cervus elaphus*, i3 droite; 3. *Ursus spelaeus*, M2 droite; 4. *Ursus spelaeus*, C supérieure droite; 5. *Marmota marmota*, I supérieure droite (vue linguale, labiale et occlusale); 6. *Canis lupus*, troisième vertèbre cervicale; 7. *Ursus spelaeus*, calcanéum droit; 8. *Panthera pardus*, deuxième phalange; 9. *Vulpes vulpes*, première phalange; 10. *Cervus elaphus*, première phalange; 11. *Panthera leo spelaea*, tibia droit.

different ecology between *U. spelaeus* and *U. arctos*, the deciduous teeth probably could be referred to *U. spelaeus*, *U. arctos* preferring small dens for dormancy, while *U. spelaeus* commonly used large caves (Kurtén, 1976).

The abundance of carnivores in the cave could be the result of selective use of the cave by these taxa, but error sampling due to the limited number of the remains or anthropic selection cannot be excluded until more accurate taphonomic analysis are available.

3.2. Small mammals

Ciota Ciara cave is unique in the Italian Peninsula context because of the relatively high abundance of *Pliomys coronensis*, and the high biodiversity of bats (Fig. 3). The Simpson index of Evenness indicates that in both Units, the biodiversity is high and relatively equally distributed (S.U. 14: 0.88 and S.U. 13: 0.86) (Fig. 4B).

The presence of one sample identified as *Erinaceus* sp. is remarkable. It is a right P4 and, based on the samples present in our collection, falls more into the size range of present *Erinaceus roumanicus* than that of *E. europaeus*. Unfortunately, the lack of specific works on the dental differences (especially on P4 measurements and morphology) between these two species does not allow a specific determination.

In Fedele (1966), only few remains of *Sorex* gr. *araneus*, *Chionomys nivalis*, *Microtus arvalis*, *Arvicola* sp. and *Glis glis* have been signalled in a trench (Trench II) excavated in the interior of the cave, approximately 20 m far from the 2009-2014 investigated area.

In S.U. 103, only two specimens of *Pliomys coronensis* have been found. S.U. 13 and 14 are both dominated by *Clethrionomys glareolus* which, together with *Apodemus* (*Sylvaemus*), *Glis glis*, *Eliomys quercinus* and the bats, contributes to the forest component (W). Thus, the environment surrounding the cave was dominated by

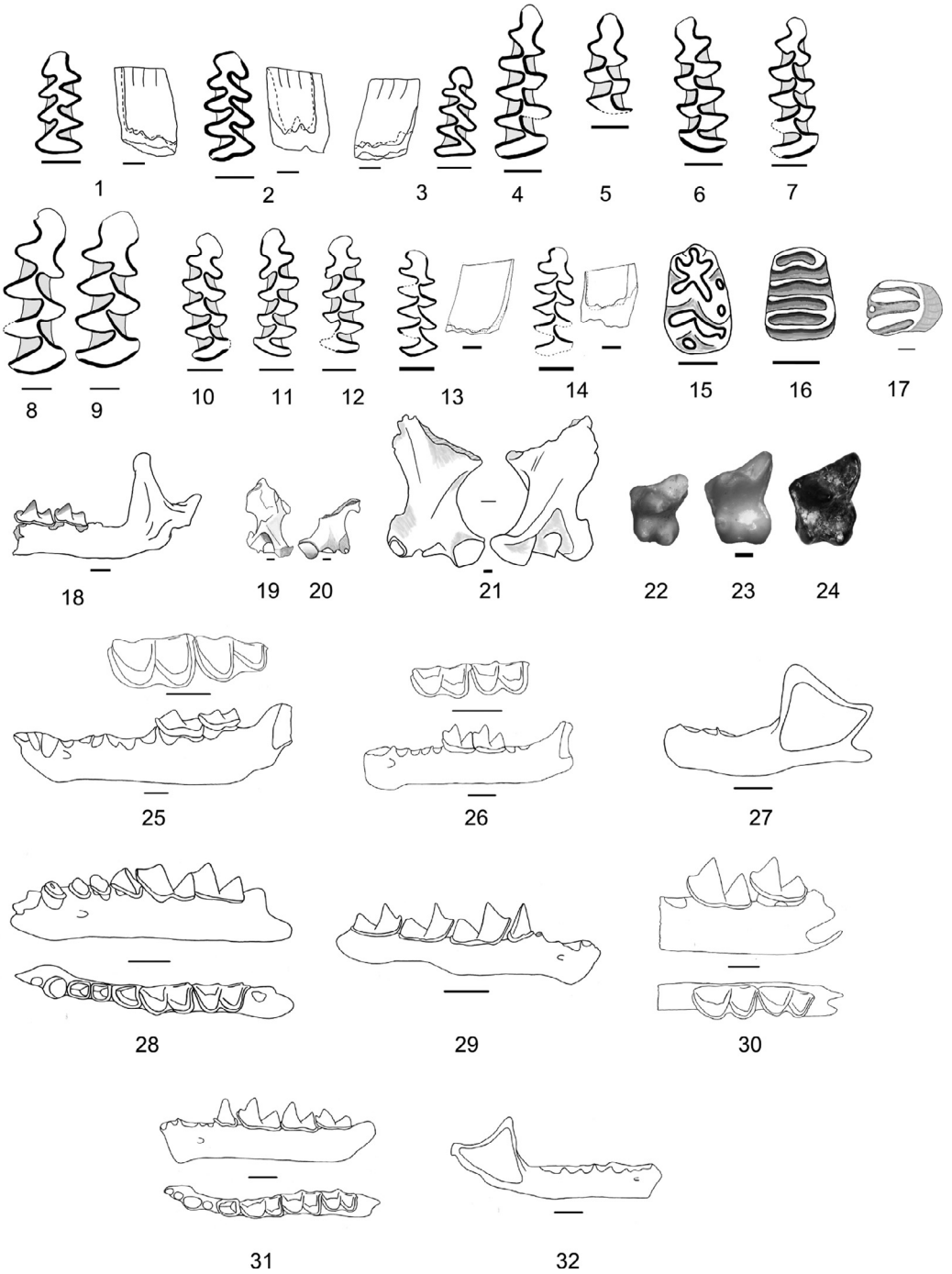

Fig. 3. Some small mammals identified from Ciota Ciara cave, S.U. 14 (excluding numbers 21 and 22 that present specimens coming from the Ferrara University collection), all scales are 1 mm long. 1. *Clethrionomys glareolus*, left m1 (occlusal view and labial view with linea sinuosa); 2. *Clethrionomys glareolus*, right m1 (occlusal view and labial view with linea sinuosa); 3. *Clethrionomys glareolus*, right m1 (occlusal view and labial view with linea sinuosa); 4. *Microtus arvalis*, right m1; 5. *Microtus arvalis*, right m1; 6. *Microtus arvalis*, left m1; 7. *Microtus agrestis*, right m1; 8. *Arvicola amphibius*, right m1; 9. *Arvicola amphibius*, right m1; 10. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, right m1; 11. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, left m1; 12. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, left m1; 13. *Pliomys coronensis*, right m1 (occlusal view and labial view with linea sinuosa); 14. *Pliomys coronensis*, right m1 (occlusal view and labial view with linea sinuosa); 15. *Apodemus* (*Sylvaemus*) gr. *sylvaticus-flavicollis*, right m1; 16. *Muscardinus avellanarius*, right m1; 17. *Sciurus vulgaris*, right M2; 18. *Sorex* ex gr. *araneus*, left mandible with m1 and m2; 19. *Talpa* cf. *caeca*, right humerus; 20. *Talpa* cf. *caeca*, right humerus; 21. *Talpa* cf. *europaea*, left humerus; 22. *Erinaceus europaeus*, left P4; 23. *Erinaceus roumanicus*, left P4; 24. *Erinaceus* sp., left P4; 25. *Myotis* gr. *myotis-blythii*, left mandible with m2 and m3 (labial and occlusal view); 26. *Myotis* sp., left mandible with m1 and m2 (labial and occlusal view); 27. *Myotis* sp., left mandible (labial view); 28. *Minopterus schreibersii*, left mandible (labial and occlusal view); 29. *Rhinolophus* cf. *hipposideros*, left mandible (labial view); 30. *Rhinolophus ferrumequinum*, left mandible with m2 and m3 (labial and occlusal view); 31. *Rhinolophus* gr. *euryale-mehelyi*, left mandible (labial and occlusal view); 32. *Plecotus* gr. *auritus-austriacus*, right mandible (labial view).

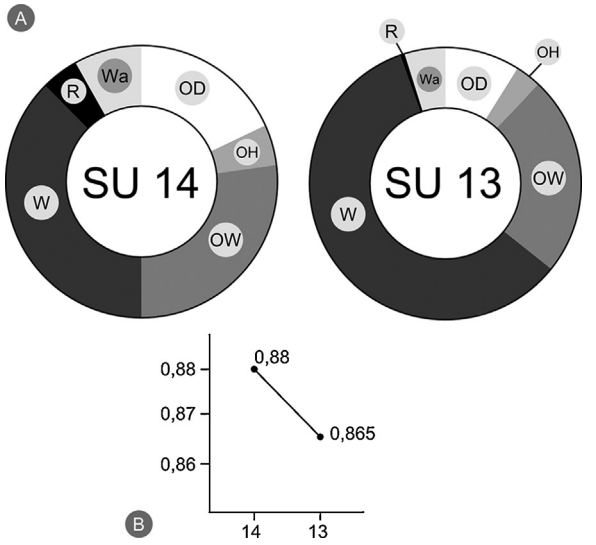

Fig. 4. Top: representation of landscape percentages (OD: Open Dry meadows; OH: Open Humid meadows; OW: Open Woodland, forest patches; W: Woodland; R: Rocky; Wa: Water, areas along streams, lakes and ponds). Bottom: Simpson index of Evenness based on small mammals assemblage.
Fig. 4. En haut : représentation des pourcentages correspondant aux types de paysages (OD : prairies ouvertes sèches ; OH : prairies ouvertes humides ; OW : forêt ouverte, lopin de forêt ; W : forêt ; R : rocheux ; Wa : eau, zone située le long des ruisseaux, des lacs et des étangs). En bas : indice d'égalité de Simpson basé sur l'assemblage de micromammifères.

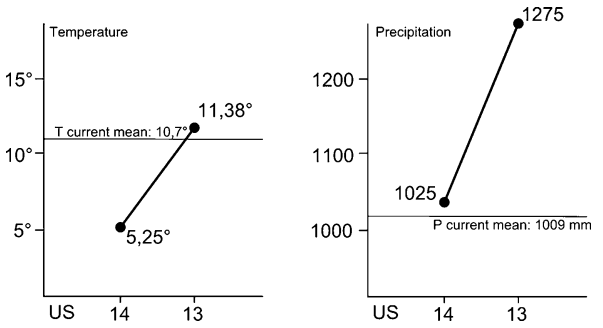

Fig. 5. The mean annual temperature (MAT) and the mean annual precipitation (MAP) from the Ciota Ciara cave (Mutual Climatic Range method).
Fig. 5. Température moyenne annuelle (MAT) et précipitation moyenne annuelle (MAP) de la grotte Ciota Ciara (méthode du *Mutual Climatic Range*).

woodland, woodland margins and forest patches (Fig. 4). These considerations are confirmed by the presence of typical woodland small mammals such as *Glis glis* and *Sciurus vulgaris*, the latter rather rare in Late Pleistocene sequences because of its diurnal habits (Berto, 2012). Also, the chiropters found in Ciota Ciara cave confirm the presence of these kind of habitats. Species as *Rinolophus hipposideros*, *R. ferrumequinum*, *Barbastella barbastellus* and *Plecotus* sp. normally hunt in wooded areas, while *Myotis myotis* prefers grassland environments. Although the chiropters have different habits than the other small mammals, these species are considered sedentary, their areal varies from 15 to 30 km from the nest, even though sporadic migration up to 50 km are registered.

Nevertheless, a climatic change is visible along these two Stratigraphic Units. The environment was more open during the deposition of S.U. 14 and the cave was surrounded by an open woodland environment with exposed rocks. In this Unit percentages of *Microtus arvalis* and *M.* (*Terricola*) gr. *multiplex-subterraneus* are high (16,11% and 13,37% respectively) and cold climate indicators, such as *Cricetus cricetus*, *Microtus* cf. *gregalis* and *Chionomys nivalis*, are present, although rare. The change to a more temperate climate is confirmed also by temperatures (MAT) and precipitations (MAP) (Fig. 5), even though this result must be considered with prudence, given the few interpolations found with the Mutual Climatic Range. It is possible to observe an improvement in climatic conditions, but the temperature for S.U. 14 indicates a "pleniglacial" condition that does not entirely reflect the situation visible in the faunal assemblage. *Clethrionomys glareolus* always stands as the most represented arvicolid. This is a strong indicator of a forested environment and the species can be underrepresented in the thanatocoenoses because it lives in bushes and it is considered difficult to pray. In addition, bats related to wooden environments are constantly present. The linear regression method tested on our sample shows that The MAT oscillation is less severe (S.U. 14, MAT = 9.4 °C; S.U. 13, MAT = 11 °C) while the MAP is much higher (S.U. 14, MAP = 1756 mm; S.U. 13, MAP = 1933 mm) but it must be noted that the standard deviation of this method is high (3.367 °C and 470.615 mm respectively, data inferred from Hernández Fernández, 2004).

4. Chronological considerations

Although radiometric dates are not yet available, some chronological considerations can be inferred based on

Fig. 3. Quelques exemples de micromammifères identifiés à Ciota Ciara, U.S. 14 (excepté les numéros 21 et 22, qui correspondent à des spécimens provenant de la collection de l'université de Ferrare), échelle = 1 mm. 1. *Clethrionomys glareolus*, m1 gauche (vue occlusale et vue labiale avec linea sinuosa) ; 2. *Clethrionomys glareolus*, m1 droite (vue occlusale et vue labiale avec linea sinuosa) ; 3. *Clethrionomys glareolus*, m1 droite (vue occlusale et vue labiale avec linea sinuosa) ; 4. *Microtus arvalis*, m1 droite ; 5. *Microtus arvalis*, m1 droite ; 6. *Microtus arvalis*, m1 gauche ; 7. *Microtus agrestis*, m1 droite ; 8. *Arvicola amphibius*, m1 droite ; 9. *Arvicola amphibius*, m1 droite ; 10. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, m1 droite ; 11. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, m1 gauche ; 12. *Microtus* (*Terricola*) gr. *multiplex-subterraneus*, m1 gauche ; 13. *Pliomys coronensis*, m1 droite (vue occlusale et vue labiale avec linea sinuosa) ; 14. *Pliomys coronensis*, m1 droite (vue occlusale et vue labiale avec linea sinuosa) ; 15. *Apodemus* (*Sylvaemus*) gr. *sylvaticus-flavicollis*, m1 droite ; 16. *Muscardinus avellanarius*, m1 droite ; 17. *Sciurus vulgaris*, M2 droite ; 18. *Sorex* ex gr. *araneus*, mandibule gauche avec m1 et m2 ; 19. *Talpa* cf. *caeca*, humérus droit ; 20. *Talpa* cf. *caeca*, humérus droit ; 21. *Talpa* cf. *europaea*, humérus gauche ; 22. *Erinaceus europaeus*, P4 gauche ; 23. *Erinaceus roumanicus*, P4 gauche ; 24. *Erinaceus* sp., P4 gauche ; 25. *Myotis* gr. *myotis-blythii*, mandibule gauche avec m2 et m3 (vues labiale et occlusale) ; 26. *Myotis* sp., mandibule gauche avec m1 et m2 (vues labiale et occlusale) ; 27. *Myotis* sp., mandibule gauche (vue labiale) ; 28. *Minopterus schreibersii*, mandibule gauche (vues labiale et occlusale) ; 29. *Rhinolophus* cf. *hipposideros*, mandibule gauche (vue labiale) ; 30. *Rhinolophus ferrumequinum*, mandibule gauche avec m2 et m3 (vues labiale et occlusale) ; 31. *Rhinolophus* gr. *euryale-mehelyi*, mandibule gauche (vues labiale et occlusale) ; 32. *Plecotus* gr. *auritus-austriacus*, mandibule droite (vue labiale).

Table 4
SDQ and SDQ3 results based on *Arvicola amphibius* from Ciota Ciara cave.
Tableau 4
Résultats de SDQ et SDQ3 basés sur *Arvicola amphibius* de la grotte Ciota Ciara.

	n	Min.	Mean	Max.	SD
SDQ	4	102.68	105.61	111.47	3.99
SDQ3	6	86.67	105	122.35	14.66

the mammal assemblage of this site. Small-mammal assemblages strongly related to woodland or woodland margins environment are rare in sites correlated to more recent chronological periods such as MIS 3 in northern Italy. Generally, these small mammals assemblages are characterized by open environment species with high percentages of *Microtus arvalis* (Berto, 2012). Around 50 km far from Ciota Ciara cave, the Caverna Generosa site (1450 m a.s.l.) displays a typical MIS 3 northern Italian small mammals assemblage. The sequence is dominated by *Microtus arvalis* during stadial oscillations (group III of "Sala Terminale" and "lev. Cun III-II") and by *M.* (*Terricola*) gr. *multiplex-subterraneus* during interstadials (groups II and I of "Sala Terminale" and "lev. Cun VI"). *Sciurus vulgaris* and *Glis glis* are absent and *Clethrionomys glareolus* increases in percentage only during the warmer oscillations, but it never dominates the association (Bona et al., 2009).

Reported for the first time in Europe during the Middle Pleistocene (Cuenca-Bescós et al., 2010), *Pliomys coronensis* in Italy is widespread in the north-eastern region during this Age (Bartolomei and Pasa, 1969; Dalla Valle, 2011). In Europe, this species reduces its areal at the beginning of Late Pleistocene to become a relict in Iberian Peninsula until its disappearance during the Last Glacial (Cuenca-Bescós et al., 2010). From the Late Pleistocene in Italy, *Pliomys coronensis* is reported only at Ponte di Veia A (Lessini Mountains, Verona) and Grotta del Vento (Central Italy, Ancona) in sediments dated around the end of MIS 5 (Esu et al., 1990; Pasa, 1950) and only one specimen seems to be present at Fumane Cave in a unit correlated to MIS 3 (Bartolomei et al., 1992). The population of *Pliomys coronensis* found at Ciota Ciara cave is one of the largest in the Italian Peninsula. The relatively strong presence of this species can be considered an indication that the sequence has been accumulated during the MIS 5.

The mean of SDQ3 index, based only on six specimens of *Arvicola amphibius*, is 105 and the index varies, in our assemblage, from 87 (SDQ_{min}) to 122 (SDQ_{max}). The SDQ (N = 4) displays a similar mean value, although slightly higher (Table 4). In Europe, the MIS 5 is characterized by the transition from *Arvicola mosbachensis* to *Arvicola amphibius*, with values of SDQ index around 100 characteristic for latest Eemian and earliest Weichselian localities (Koenigswald von, 1994; Koenigswald von and Heinrich, 1999; Koenigswald von and Kolfschoten van, 1996). In this context, considering altitude, latitude and the probability of immigration events during Eemian (and the consequent increase of SDQ), the SDQ and SDQ3 Ciota Ciara sample values could be considered as transitional. This data alone could not provide strong evidence for precise dating, but they can concur with others to support the chronological hypothesis proposed of an accumulation occurred during a final phase of MIS 5.

5. Conclusions

The small and large mammal association of Units 13 and 14 of Ciota Ciara cave (Borgosesia, Vercelli) is one of the most complete of the Piedmont region. The environment surrounding the cave during the deposition of the S.U. was dominated by woodland, woodland margins and forest patches and it seemed to be more open during the deposition of S.U. 14. The climate was similar to the present one in S.U. 13 and colder in S.U. 14.

Among the small mammals, *Pliomys coronensis* is relatively abundant, and has a higher contribution than at any of the other Italian Peninsula sites where this species has been reported. This species, together with the SDQ analyses and the general mammal association seems to indicate that the deposition of S.U. 13 and 14 happened during the MIS 5 (after the Eemian interglacial).

This makes Ciota Ciara cave one of the few sites for MIS 5 in northern Italy. It gives precious insight into palaeoclimatic and palaeoenvironmental conditions of an area that is otherwise poorly known in the context of Upper Pleistocene mammal assemblages.

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