International Journal of Osteoarchaeology
Int. J. Osteoarchaeol. **14**: 273–286 (2004)
DOI: 10.1002/oa.761

Ecology and Subsistence Strategies in the Eastern Italian Alps during the Middle Palaeolithic

IVANA FIORE,* MONICA GALA AND **ANTONIO TAGLIACOZZO**
Soprintendenza Speciale al Museo Nazionale Preistorico Etnografico 'L. Pigorini', Sezione di Paleontologia del Quaternario e Archeozoologia, P.le Marconi 14, 00144 Roma, Italy

ABSTRACT Italy is very rich in Middle Palaeolithic sites, and the Veneto region ranges among those with the best archaeozoological information. Most of the Middle Palaeolithic sites are located in caves and rock shelters situated at the mouths of the Alpine valleys, in the piedmont slopes. The two sites that offer the best archaeozoological data are Grotta di Fumane and Grotta S. Bernardino. Grotta S. Bernardino was occupied alternately by humans and carnivores, in particular bear. The fauna is largely dominated by ungulate remains, with red and roe deer prevalent over chamois and ibex; elk and giant deer are also present. Among the carnivores, the most frequent species is cave bear followed by lynx and leopard. Furthermore, hare, beaver and marmot are present together with remains of both fish and birds. It is possible that bears or birds of prey introduced the rare fish remains. In the Mousterian levels, hunting of the most common species was mainly directed towards young adult and adult individuals, suggesting the possibility of selective hunting. Marmot, beaver and probably bear, together with some species of birds (ducks, geese and Galliformes) were also hunted. At Grotta Fumane, Mousterian and Aurignacian levels reveal evidence of human activity related to carcass processing and bone exploitation. The most frequent ungulates are red deer, followed by roe deer and ibex; less frequent are chamois, bovids and giant deer (*Megaloceros giganteus*). Among the carnivores, bears (both *Ursus arctos* and *Ursus spelaeus*) are present, as are wolf, red fox and hyena (*Crocuta crocuta*). Hare and marmot are also present together with abundant bird remains. The most common species of bird are: *Tetrao tetrix*, *Crex crex* and *Pyrrhocorax graculus*. Mortality data for ungulates suggest that young adults and adults were preferentially selected. The faunal assemblage indicates that economic, ecological and climatic changes took place between the Mousterian and the Aurignacian levels. Copyright © 2004 John Wiley & Sons, Ltd.

Key words: Italy; hunting; Neanderthal; birds; climatic changes; archaeozoology; palaeoecology; palaeoeconomy

Introduction

Italy has a very rich Middle Palaeolithic record, represented by more than 350 sites, both in caves and the open air, ranging in time from about 130,000 to 30,000 years ago (Bartolomei *et al.*, 1984; Peretto, 1992; Milliken, 2001; Peresani, 2001a; b). They are found only in the Italian peninsula, both along the present-day coast and in the interior, in valleys and on high mountains. It is possible to recognise six geographical areas with similar morphological and environmental characteristics and concentrations of archaeological sites (Figure 1). Unfortunately, studies of the faunal remains are few because most research has focused on the typology of the retouched tools in order to assign assemblages to cultural

* Correspondence to: Soprintendenza Speciale al Museo Nazionale Preistorico del Quaternario e Archeozoologia, P.le Marconi 14, 00144 Roma, Italy.
e-mail: pigorini@arti.beniculturali.it

Received 24 March 2003
Revised 13 August 2003
Accepted 7 November 2003

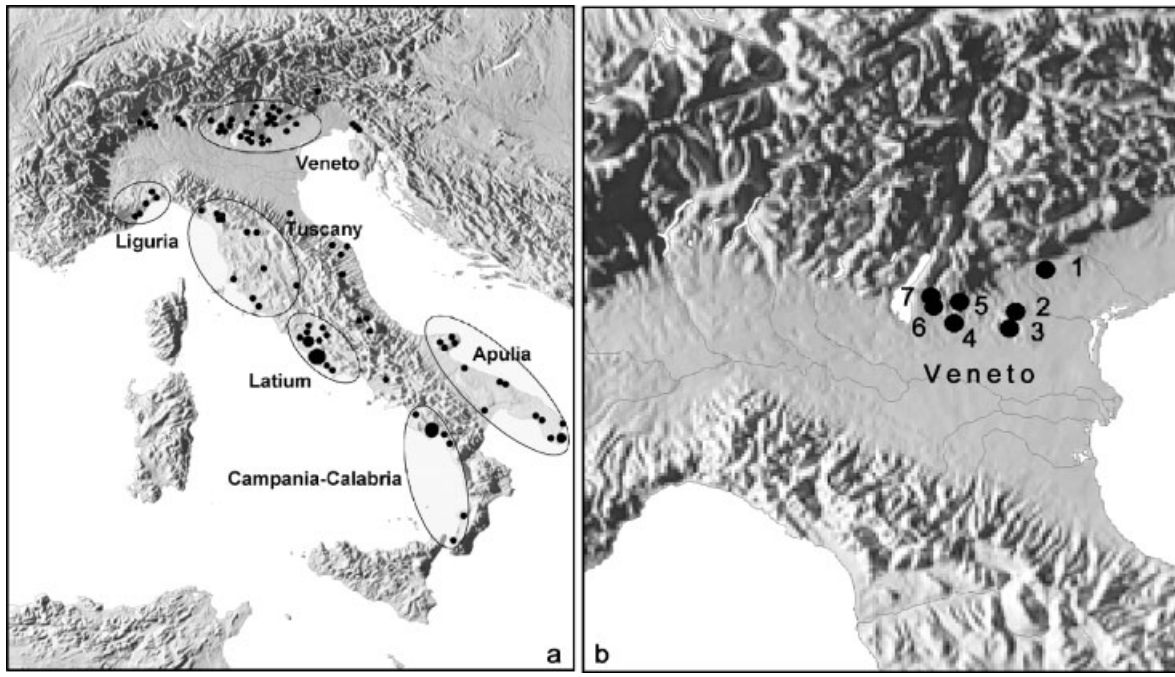

Figure 1. (a) Map of Italy showing the location of six geographical areas with similar morphological and environmental characteristics, and with concentrations of archaeological sites. (b) Detail of the Veneto region. 1: Pagnano d'Asolo; 2: Grotta del Broion; 3: Grotta di San Bernardino; 4: Riparo Mezzena; 5: Riparo Tagliente; 6: Grotta della Ghiacciaia; 7: Grotta di Fumane.

facies. Moreover, the main goal of many excavations was to dig test trenches as deep as possible, while horizontal variability was considered of secondary importance. For most sites, publication of the faunal remains consists simply of a list with the common species, often without indications of abundance (rare attempts to quantify the faunal remains are restricted to numbers of identified specimens) and with only generic ecological considerations. Very few sites have been investigated from an archaeozoological point of view.

In this work we will try to summarise the palaeontological and archaeozoological data for northeastern Italy, where the Middle Palaeolithic evidence is represented by about 60 sites and surface finds (Peretto, 1992; Milliken, 2001; Peresani, 2001a; b). Particular attention has been paid to the research undertaken at Grotta di Fumane and Grotta Maggiore di San Bernardino. Research on the Middle Palaeolithic in this area began at the end of the eighteenth century, but it was only in the 1980s that a new phase of study began, characterised by the development of surveys and excavations, and by absolute dating. Sites are located in the mountainous or hilly sectors that were only marginally touched by alpine glaciers and only partially affected by periglacial processes, or in those sectors where fluvial terraces were not damaged by destructive post-depositional processes. The Middle Palaeolithic sites are located in caves, rock shelters and the open air, but the latter are strongly affected by post-depositional processes which caused the loss of much evidence of past human activity, in particular the destruction of palaeo-living floors and animal bones. Only a few teeth attributed to Neanderthals have been found in this region (Giacobini, 1992; Villa *et al.*, 2001).

Analysis of the sites

Evidence of Neanderthal activity exists in four distinct zones: open-air sites in the Alps (1300–1800 m asl); open-air sites in the high Monti Lessini and Altopiano di Asiago (900–1600 m asl); caves and rock shelters in the lower Monti Lessini and the Colli Berici

(135–600 m asl); and open-air sites at the foot of the Venetian Pre-Alps (100–200 m asl). The faunal remains are all found in caves and rock shelters in the lower Monti Lessini and the Colli Berici (135–600 m asl), with the exception of the rare mammoth remains from Pagnano d'Asolo. These caves are characterised by thick stratigraphic sequences which suggest that the sites were reoccupied over long periods of time. The Mousterian industry is characterised by the Levallois technique and is very homogeneous in the whole area (Peretto, 1992). Its typological aspects and its evolution can be followed in the sequence of Riparo Tagliente.

The analysis of the faunal assemblages of Grotta Maggiore di San Bernardino and of Grotta di Fumane were performed by A.T. (Cassoli & Tagliacozzo, 1994a, b). Faunal remains were collected in both excavations using water sieving with a mesh size of 2 mm. All remaining data used for the present study were obtained from the literature (see references); no information is provided by the authors on excavation techniques.

Riparo Tagliente

Riparo Tagliente (Grezzana, Valpantena, Verona), located 250 m above sea-level (asl) in the Monti Lessini, is considered the type site for the Mousterian in the Veneto region (Bartolomei *et al.*, 1982). The whole stratigraphic series, referable to the top of the Upper Pleistocene, is divided into two main units separated by an erosion surface: (i) deposits bearing Mousterian and Aurignacian industries; (ii) deposits bearing Epigravettian industries. Therefore, two cycles of human occupation are represented, during which times the site was repeatedly reoccupied. The lower levels (levels 52 to 31), about 3 m thick in total, contain Mousterian industry. At the top of the series, level 25 contains Aurignacian industry with Dufour bladelets. Geological, biological and lithic typological data suggest that the whole series corresponds with an entire glacial cycle, between about 60,000 and 30,000 years ago (Bartolomei *et al.*, 1982, 1984; Guerreschi *et al.*, 2002). Site excavation is still in progress, and so far only a small portion of the Mousterian deposits has been investigated. Unfortunately, only a small sample of macromammals (N = 2106 fragments) from the upper levels of the Mousterian sequence has so far been analysed (Number of Identified Specimens [NISP] = 306). The abundance of roe and red deer, and the presence of elk and marmot, suggests a moderately humid, temperate-cold climate (Table 1). The frequency of human modifications of ungulate remains indicates that Neanderthals played an important role in the accumulation of the faunal assemblage (Thun Hohenstein *et al.*, 2001). The presence of a significant number of foetal/neonatal ungulate bones suggests that human occupation occurred in the spring.

From a climatic point of view the study of the micromammals is much more complete and allows us to recognise at least three climatic cycles (Bartolomei *et al.*, 1982). The Mousterian sequence begins with a phase where several different habitats can be identified: forest, woodland areas and wide open steppe-grasslands. A marked change can be observed at level 44–40 where the strictly forest-dwelling species disappear and continental Asian steppe species (*Microtus gregalis*, *Ochotona* cf. *pusilla*, *Sicista* sp., *Cricetus cricetus*) are well-represented. These levels represent the period of greatest dryness. In the upper part of the sequence, forest and woodland micromammals reappear, but they are less numerous than the open grassland or woody grassland forms. For the macromammals, the most significant discovery is the presence of two fragments of enamel lamellae of young mammoth (*Mammuthus primigenius*) (Bartolomei *et al.*, 1982). These are the only Italian mammoth specimens found so far that are clearly associated with Mousterian lithic industry, within a well-established stratigraphic context.

Pagnano d'Asolo

Remains of a skeleton of *Mammuthus primigenius* were found in 1878 together with a few flakes 'of Mousterian type' (Dal Piaz, 1931) in the alluvial deposits near Pagnano d'Asolo (in the piedmont of the Lessini mountains, Asolo, Treviso). A large part of the skeleton is preserved, including the tusks, and it is identified as an adult female, between 25–32 years old (Reggiani & Sala, 1992).

Table 1. Remains of mammals from the sites analysed in this paper (x = present; xx = abundant). Grotta di San Bernardino (Cassoli & Tagliacozzo, 1994a); Grotta del Broion (Sala, 1980, 1990); Grotta della Ghiacciaia (Sala, 1990; Peresani *et al.*, 2001); Riparo Mezzena (Bartolomei *et al.*, 1980; Sala, 1990); Riparo Tagliente (Thun Hohenstein *et al.*, 2001); Grotta di Fumane (Cassoli & Tagliacozzo, 1994b, and present work)

Species	San Bernardino (NISP)			Broion (NISP)			Ghiacciaia (NISP)	Mezzena (NISP)	Tagliente (%)	Fumane (NISP)		
	VI	V–IV	III–II	R	Q–O	N–I	32–41	II–III	37	S	BR	A
Marmota marmota	16	3	4		6	12	1	xx	2.5	*7*	11	9
Castor fiber	25	5	14									1
Hystrix cristata												1
Lepus europaeus					2	1						
Lepus cf. *timidus*												
Lepus sp.	3		2				1				16	2
Canis lupus	3	1	2		6	108	4	1	*1.2*	23	38	23
Vulpes vulpes	7	4	2	1	8	9	2	2	*0.5*	5	15	38
Alopex/Vulpes												9
Felis silvestris	1	1			1			1				
Lynx lynx	6	1	3							1	7	
Panthera leo					1						3	
Panthera pardus	1									1		3
Crocuta crocuta								1			1	5
Lutra lutra		1	1									
Meles meles					1	1						
Martes martes				7	52	21						
Martes sp.	1	1	3						*0.2*	1	1	1
Mustela erminea						1						
Mustela nivalis					5	1						
Mustela putorius	2		3		3	1						
Mustela sp.												7
Ursus spelaeus	89	53	13		x	xx		2				5
Ursus arctos	2					9		2				9
Ursus sp.	40	39	5				7			29	95	36
Equus caballus												1
Stephanorhinus sp.	1											
Sus scrofa	32							1				2
Cervus elaphus	91	32	27	2	8	14		9	*12.5*	346	743	601
Capreolus capreolus	173	15	105				2	4	*62.3*	347	191	329
Alces alces	24	2	7		4	1			*1.5*			
Alces vel Megaloceros	35	3	6									
Megaloceros cf. *giganteus*	2		1							9	60	67
Cervidae	76	26	6					2	*4.3*			2
Bison priscus			1				2					
Bos primigenius	1								*0.7*			
Bos vel Bison	18	5	4		4	5	1	3	*2.3*	5	17	42
Capra ibex	1	6	5	32	167	4	6		*3*	196	183	156
Rupicapra rupicapra	28	36	48	7	44	9			*9*	11	81	61
Caprinae	8	2	7									
Total	686	236	269	49	312	197	26	28	*100%*	981	1462	1410

Riparo Mezzena

The rock-shelter of Riparo Mezzena lies at 250 m asl on the Lessini mountains, near the town of Verona. The deposits (about 1.5 to 1.7 m thick) were excavated in 1957 (Palma di Cesnola, 1961) and are composed of an alternating sequence of sterile and archaeologically rich layers containing macrofaunal bones associated with a lithic industry. The sequence, according to sedimentary and palaeobotanic evidence, can be divided into three levels: the basal layer III shows traces of intense human activity, while the anthropogenic content markedly diminishes in layer II. Layer I is a more recent deposit, with the presence of domestic goat and dog (Bartolomei *et al.*, 1980).

The fauna of layers III–II (Sala, 1990) is characterised by the presence of red deer, roe deer,

giant deer, wild boar, and several carnivores (wolf, fox, wild cat, bear and hyena) together with abundant marmot and micromammal remains (Table 1). The absence of ibex and chamois, usually present in the area during the Upper Pleistocene, is difficult to explain. The abundance of marmot remains might be due to a later den (Bartolomei *et al.*, 1980; Sala, 1990). Forest forms dominate the macro-and micromammal assemblages, but typical continental or steppe rodents are also present (e.g. *Sicista* and *Cricetus*). This evidence suggests that site occupations could date to the early part of Oxygen Isotopic Stage (OIS) 4.

Grotta della Ghiacciaia

The Grotta della Ghiacciaia, located in the Lessini mountains at 250 m asl (Fumane, Verona), was excavated in 1979–80 (Bartolomei *et al.*, 1984). The deposit (about 3.5 m thick) is divided into three stratigraphic series. The most ancient is referable to the last interglacial period, while the remaining two units are dated to the beginning of OIS 4 and include faunal remains and Mousterian lithic industry of Levallois type. Chronology is based on sedimentological and palaeobotanical evidence (Peretto and Thun Hohenstein, 2002). Ungulate remains (ibex, roe deer and bison) are very scarce and very fragmentary (Sala, 1990) (Table 1), and no traces of carnivore activity have been found, although cave bear, wolf and fox were occasionally present in the cave (Peresani *et al.*, 2001). In contrast, Neanderthal butchery and intentional breakage of the bones are documented. Some of the bones were also used as retouchers for stone tools. Similar specimens were also found in most other caves of this area.

Grotta del Broion

Nine metres of deposit were excavated at Grotta del Broion (Lumignano, Colli Berici, Vicenza), at 150 m asl. At the bottom layer S, only *Capra ibex* bones are present (Table 1); some of them are still in anatomical connection and are not associated with evidence of human activity (Sala, 1980, 1990). Occasional frequentation during the Mousterian is indicated in levels R to I. C^{14} dating of level I (Bartolomei *et al.*, 1984; Milliken, 2001) gave the following results: $33{,}800 \pm 1300$; $40{,}600 \pm 1200$ (GrN-4638); $46{,}400 \pm 1500$ (GrN-4638). Bone remains are not particularly abundant, except those of cave bear and other carnivores such as the wolf. No taphonomic studies have been carried out so far, therefore the role of humans in the accumulation of the faunal assemblage is not clear.

In the lower level R, there is a striking prevalence of ibex and chamois, and a relative lack of red deer, indicating an arid, alpine grassland environment. Similar environmental conditions prevail in levels Q–O, where the presence of elk and bovines, and especially of some mustelids, suggests an increase in humidity and forest cover. A clear climatic environmental change is evident in levels N–I where it is possible to note the increase of red deer (Sala, 1980; 1990).

Grotta Maggiore di S. Bernardino

At Grotta Maggiore di S. Bernardino (Mossano, Colli Berici, Vicenza) there are Middle Pleistocene deposits followed by early Upper Pleistocene levels containing Mousterian lithic assemblages (Leonardi & Broglio, 1961; Peresani, 1995–96). Some layers were intensively occupied by humans, with traces of hearths, lithic industry and fauna. The systematic excavations, which began in 1959, were continued in a second phase in 1986 and finished in 1994. The study of the stratigraphic series allowed the identification of a succession of three main palaeoclimatic cycles (Peresani, 2001a,b). The oldest cycle (units VIII–VII, levels L–H), on the basis of the U/Th and electron spin resonance (ESR) age (unit VIII: 202 ± 30 ka; unit VII: 156 ± 23 ka,), dates to the late Middle Pleistocene; the intermediate (units VI–IV, levels G–C) and most recent (units III–II, level B) cycles are dated to the Upper Pleistocene (unit IV: 108 ± 16 ka; unit II: 33 ± 5 and 38 ± 5 ka). The intermediate cycle seems to be characterised by temperate climatic conditions with broadleaf, wooded landscapes, some open spaces and wetlands (unit VI); this period was followed by a colder climatic phase (units V–IV)

which resulted in the formation of a steppe environment. The most recent cycle is represented by a humid phase (which caused water erosion of unit III) and the diffusion of a wooded landscape (unit II) (Peresani, 2001a, b).

A total of over 14,000 bone remains have been analysed, of which only 10.1% could be determined to either the species or genus level: about 50% of the sample is composed of small bone splinters shorter than 1 cm in length. The fauna is largely dominated by ungulate remains, with red and roe deer prevailing over chamois and ibex; elk and giant deer are also present (Bartolomei, 1960; Sala, 1990; Cassoli & Tagliacozzo, 1994a) (Table 1). Among the carnivores, the most frequent species is cave bear followed by rarer fox, wolf, mustelids, wildcat, lynx and leopard. A single specimen of rhinoceros and numerous wild boar remains were recovered in the most recent levels. Hare, beaver and marmot are present together with remains of fish. Abundant remains of marmot, particularly from the most recent levels, were not analysed because of the likelihood of them resulting from denning activities. Only marmot bones with a physical state coherent with the rest of the sample were analysed. The few bird bones (N = 25) include 12 species reflecting mainly an alpine wooded environment with rocky clearings (black grouse, *Tetrao tetrix* and alpine chough, *Pyrrhocorax graculus*) (Table 2). The presence of waterfowl (ducks and geese) is evidence for the existence of humid environments and watercourses close to the site.

The cave was occupied alternately by humans and carnivores, in particular bear. Gnaw and puncture marks produced by carnivores were detected only on a few bones. It is possible that the few fish remains were introduced by bear or birds of prey present in this assemblage. More numerous ungulate bones show traces related to human exploitation of the animal carcasses for alimentary purposes (Malerba & Giacobini, 1998). Cut marks on some beaver bones indicate processing for pelts. Based on the skeletal portions recovered, some of the bears were hunted, as well as bird species which do not live in caves (ducks, geese and Galliformes). However, the state of bone conservation and scarcity of skeletal elements of birds do not allow a precise determination of which predator(s) originated the fossil bone assemblage. Most of the common ungulate species are represented by young adult and adult individuals, thus suggesting human hunting activity.

From an ecological point of view, roe deer is prevalent in the lower Unit VI (levels G), with abundant chamois and presence of elk. Among

Table 2. Bird remains from Grotta San Bernardino (Cassoli & Tagliacozzo, 1994a) and Grotta di Fumane (Cassoli & Tagliacozzo, 1994b and present work)

Species	San Bernardino (NISP)			Fumane (NISP)		
	VI	V–IV	III–II	S	BR	A
Anser anser			1			
Anas platyrhynchos		2	2			1
Anas querquedula	1		1			
Aegypius monachus						1
Buteo buteo		1				
Aquila chrysaetos	1				3	2
Falco tinnunculus				1		5
Falco vespertinus					1	4
Falco subbuteo	1					5
Falco eleonorae				1		
Lagopus cf. *mutus*						2
Tetrao tetrix	1	1	2	3	7	57
Alectoris graeca			3			1
Perdix perdix				5	1	2
Coturnix coturnix						8
Rallus aquaticus						2
Crex crex				1	4	55
Gallinula chloropus						1
Recurvirostra avosetta						1
Scolopax rusticola						2
Athene noctua	1					
Asio otus					1	22
Aegolius funereus						2
Apus melba	1					
Dendrocopus leucotos						1
Ptyonoprogne rupestris				2		
Turdus pilaris						3
Turdus iliacus						2
Turdus viscivorus					2	9
Oriolus oriolus						1
Garrulus glandarius						4
Pica pica				2		3
Nucifraga caryocatactes			1			
Pyrrhocorax graculus			5	31	22	169
Pyrrhocorax pyrrhocorax						1
Corvus monedula					1	
Corvus corone						2
Corvus corax						1
Montifringilla nivalis				5		4
Loxia curvirostra				2		1
Pinicola enucleator						1
Total	6	4	15	53	42	375

the other mammals there is a relatively high frequency of beaver and presence of marmot. Among the birds there is a notable absence of corvids (cold climate) and presence of aquatic birds and species typical of mountain woodlands. The environment is mainly wooded, with some wide open and humid areas. The climate was temperate but with a tendency towards cold conditions. Units V–IV (levels F–C) show a decline in cervids, the diffusion of caprines and a marked increase in cave bear remains, as well as the presence of marmot. The mammal assemblage reflects an open habitat with colder and more arid climate; the presence of humid zones is indicated by the beaver, the otter and the mallard. In units III–II (level B) there is a marked increase in cervids, and the first appearance of wild boar, as well as the presence of elk and beaver. Among the few caprines, chamois is more prevalent than ibex. The presence of hare, marmot and, among the birds, alpine chough, nutcracker and black grouse, indicates an alpine environment, and a humid phase with a temperate-cold climate, with a woodland environment in the presence of alpine grasslands.

Grotta di Fumane

The Grotta di Fumane is located in the Lessini Mountains (Veneto Pre-Alps) at 350 m asl. Systematic excavations were started in 1988 by A. Broglio and M. Cremaschi. The cave, which is 13 m deep and 4 m wide at the entrance, was almost completely filled up by nearly 10 m of Upper Pleistocene sediments. When research originally started the entrance was hidden by detrital deposits. Excavations have concentrated on the entrance and the area in front of the cave; so far the Aurignacian levels (A3–A1, D7–D1c base) have been excavated over a surface of 40 m^2, while the underlying Mousterian levels (S, BR, A12–A4II) have been excavated down to bedrock over a much smaller area. The interior of the cave is known to contain bones and lithic artefacts, but is not yet excavated (Peresani & Sartorelli, 1998; Broglio & Cremaschi, 1998–99; Broglio, 2001).

The lower occupation levels contain Mousterian assemblages, the most recent ones (A12–A4II) characterised by Levallois debitage (Peresani & Sartorelli, 1998). Above, a thin level (A4I) contains an assemblage with an Uluzzian type backed piece. Levels A3 to D1c-base show an intense Aurignacian occupation. The final, uppermost levels of the cave (D1c and D1d) show rare traces of human activity, abundant evidence of carnivore presence and few Gravettian stone tools. The Aurignacian and Mousterian living-floors can be grouped into four lithological and pedological macro-units (Broglio & Cremaschi, 1998–99; Broglio, 2001; Broglio *et al.*, 2002; Peresani & Tagliacozzo, 2002). The Mousterian levels, dated between 80,000 and 38,000 years BP, are included in three units in the lower–middle part of the deposit: S (S9–S1), mainly residual sands with boulders and stones, originating under the influence of a damp but unstable temperate climate (level S7: TL age 79 ± 13 ka); BR (BR12–1), thermoclastic breccia with loess marking a climatic shift towards cooler conditions (level BR11: TL age 57 ± 8 ka; level BR 12: TL age 55 ± 7 ka); A (A12–A4II), thermoclastic breccia originating during a moderately damp temperate climate which became progressively cooler and drier (level A6: $50{,}000 \pm 8000$ TL age; levels A5+A6: C14 age $38{,}250 \pm 700$ and $38{,}8000 \pm 750$) (Peresani, 2001a; Broglio *et al.*, 2002).

So far, only the bones collected from 1988 to 1996 have been analysed. In total, about 7500 of the bones ($\sim$4.5% of the total number of remains, N = 160,000) have been identified to species and/or genus level. In the Mousterian and early Aurignacian levels, bone remains are the result of human activity, but there is certainly a contribution from large carnivores judging by the presence of gnaw marks (Cassoli & Tagliacozzo, 1992, 1994b; Malerba & Giacobini, 1995). For the main ungulate species all skeletal elements are present, suggesting the introduction of complete carcasses. The taphonomic analysis detected traces of human activity related to carcass processing and bone exploitation (Malerba & Giacobini, 1995). The frequency and localisation of these traces allowed recognition of repetitive patterns for some actions. Bone fragmentation is more evident in the Mousterian levels than in the Aurignacian ones. Relatively more evidence of bone burning occurs in the Mousterian levels. In

all three units the most frequent ungulates are *Cervus elaphus* and *Capreolus capreolus*, followed by *Capra ibex* (Cassoli & Tagliacozzo, 1994b) (Table 1). *Rupicapra rupicapra* and bovids are less frequent. Remains of a large cervid were attributed to the giant deer (*Megaloceros giganteus*), as suggested by morphological features that distinguish it from the elk. Among the bovids, *Bison priscus* is certainly present but most of the remains, which included several young individuals, could not be determined to species level. Only one horse and two wild boar specimens were found. Among the carnivores, both *Ursus arctos* and *Ursus spelaeus* are present, together with red fox, wolf and hyena. A specimen from the Mousterian levels attributed to *Hystrix cristata* represents the first discovery of this species, typical of warm temperate climate, during the last glaciation in northern Italy. Mountain hare and marmot are also present. Ungulate mortality data indicate that during the Mousterian, young adults and adults were preferentially selected, while in the Aurignacian there is an increase in the number of young and old individuals due to the greater influence of carnivores as bone accumulators. Carnivores are more abundant in the Aurignacian levels.

Particularly interesting is the presence, in Unit BR, of living floors where the remains of distal limbs of ibex and red deer, still in anatomical connection, were recovered. These floors have been interpreted as areas where parts discarded during skinning and butchering activities accumulated.

Remains of 35 species of bird were found; the most common species throughout the deposit are: black grouse (*Tetrao tetrix*); corncrake (*Crex crex*); and alpine chough (*Pyrrhocorax graculus*) (Table 2). There are also several species of nocturnal and diurnal raptors (mainly Long-eared Owl, *Asio otus*), Galliformes and small Passeriformes. Columbiformes, often numerous in peninsular sites where they indicate temperate climatic conditions, are absent at Fumane.

Initial taphonomic analysis indicates only uncertain anthropic marks and gnawing marks produced by carnivores. A more detailed analysis is in progress, aimed at assessing whether or not bones were digested by birds of prey. Particularly important is the presence of striations produced by a stone tool on the ungual phalanx of a golden eagle (*Aquila chrysaetos*) from the base of level A (Figure 2). The marks were probably produced when the talon, or its keratin sheath, was being removed, possibly for use as an ornament. This is the first clear evidence of human modifications on bird remains from a Mousterian site in Italy.

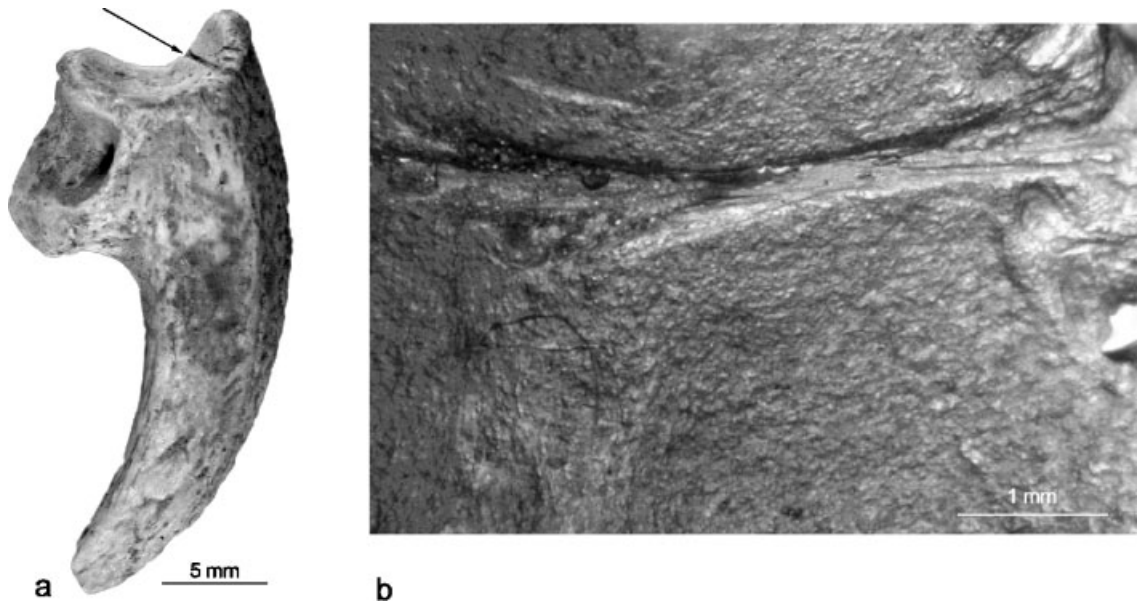

Figure 2. Grotta di Fumane. (a) *Aquila chrysaetos* ungual phalanx; the area with cut marks is indicated by the arrow. (b) Cut marks morphology as seen under stereomicroscope.

Similar striations on the third posterior phalanx of a golden eagle have previously been identified in Mousterian levels from Pech de l'Azé I in France (Mourer-Chauviré, 1975) and at the Grotte du Hyène (Mourer-Chauviré, personal communication).

The faunal assemblage contains evidence of economic, ecological and climatic changes both within the Mousterian and between the Mousterian and the Aurignacian (Cassoli & Tagliacozzo, 1994b). In lower unit S, cervid remains dominate the caprines, reflecting the wider extension of woodland habitats and a moderately temperate-humid climate (Figure 3). Periods of colder and more arid climate with more open, alpine grasslands are present in the basal part of S9 and in level S3, where remains of ibex and chamois are more numerous. This period is followed, in S2–1, by a more humid and temperate phase indicated by an increase in the number of roe deer remains. This temperate phase continues in the overlying breccia unit, where cervids dominate once again. A more marked presence of caprines is recorded beginning in BR6, with a maximum in BR1, attesting to a climatic shift towards cold and arid conditions. A cool climatic moment, with alternating forest and alpine grasslands environments, is reflected in the basal part of Unit A (A13–12) where cervids are prevalent, but where ibex, chamois and marmot are well represented. Birds indicative of open alpine environments include the alpine chough and ptarmigan. Progressive increases in the number of cervids, to the detriment of open habitat species, occurs in A11–8 and reflects a climatic shift to temperate-humid conditions and the expansion of woodland and forest habitats. The prevalence of such habitats continues until the end of the Mousterian series (level A4), with a trend towards cooler conditions.

A marked change towards a cold–arid climate is evident in the Aurignacian levels, with the development of alpine grassland and steppe environments, although humid and wooded areas

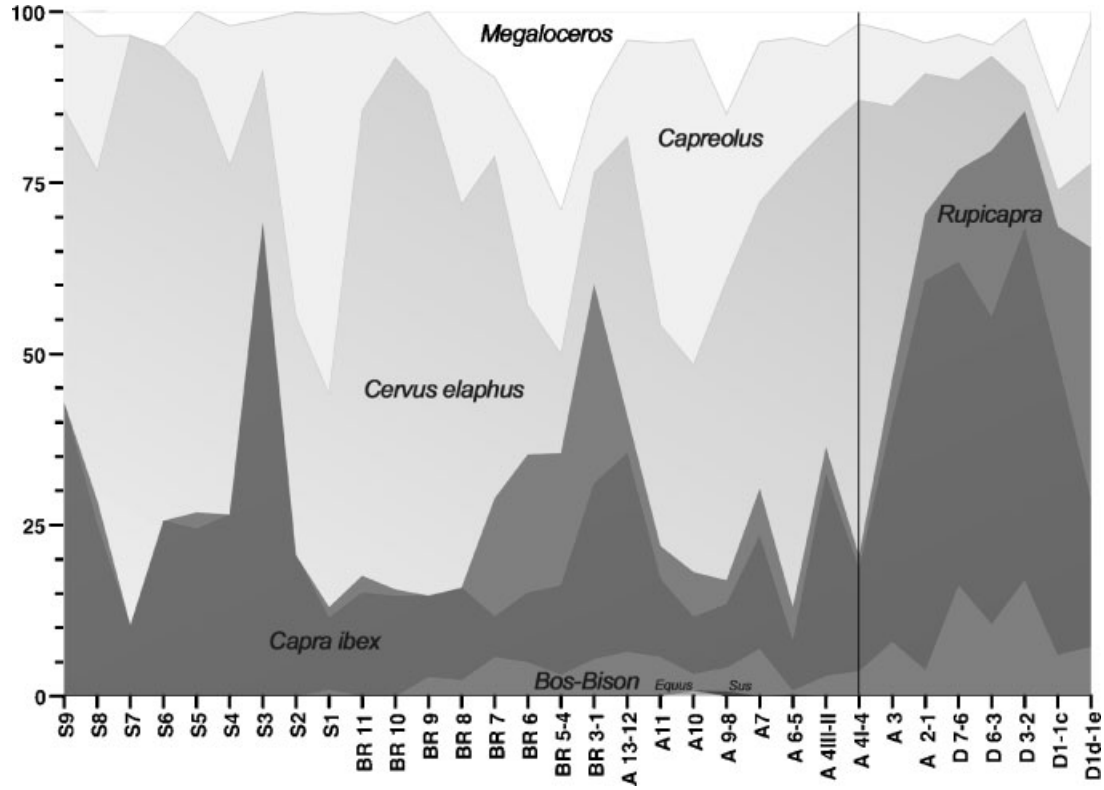

Figure 3. Grotta di Fumane. Frequency of the ungulates in the different levels of the stratigraphic sequence (Cassoli & Tagliacozzo, 1994b and present work).

are still present. In the Aurignacian levels there is also a clear increase in bird remains; some of these are probably the result of natural accumulations, indicating less intense human occupation. In these levels some 'cold' species are present, like the rough-legged buzzard (*Buteo lagopus*), the ptarmigan (*Lagopus cf. mutus*) and the snowy owl (*Nyctea scandiaca*). Furthermore, an increase in open habitat species suggests the expansion of grassland and alpine steppe.

Conclusion

Neanderthal ecology

Although the North-East is better investigated and richer in sites than other regions of Italy, few sites in this region contain animal bones, and not all have been analysed with the same methodology. Furthermore, the scarcity of absolute dates does not allow correlation between many of the sites. Where stratigraphic sequences with several occupation levels are documented, it is possible to identify variations in the frequency of different ungulates attributable to climate change (Figure 4).

It is possible to suggest the following chronological correlations between the main deposits on the basis of published radiometric dates, biostratigraphical evidence and the Mousterian lithic industries:

i. Level VI of the Grotta S. Bernardino, dating between 156 ± 23 and 108 ± 16 ka, and level R of Grotta del Broion are certainly the oldest and can be traced back to the end of the Middle Pleistocene.
ii. Levels V and IV of Grotta S. Bernardino are referable to OIS 5 (Last Interglacial).
iii. All the remaining levels are distributed between OIS 4 and 3 (80,000–40,000 years ago). In this latter period, levels S and BR from Fumane, and probably levels Q—O from Broion, are the oldest. Absolute dating allows us to establish the following sequence for the most recent levels: Broion N–I, Fumane A, S. Bernardino III–II and Tagliente level 37; however, simultaneous occupation of the different caves is probable.

The data presented here (Table 3) indicate that the main ungulates present during the Mousterian period are: *Cervus elaphus* (absent only at

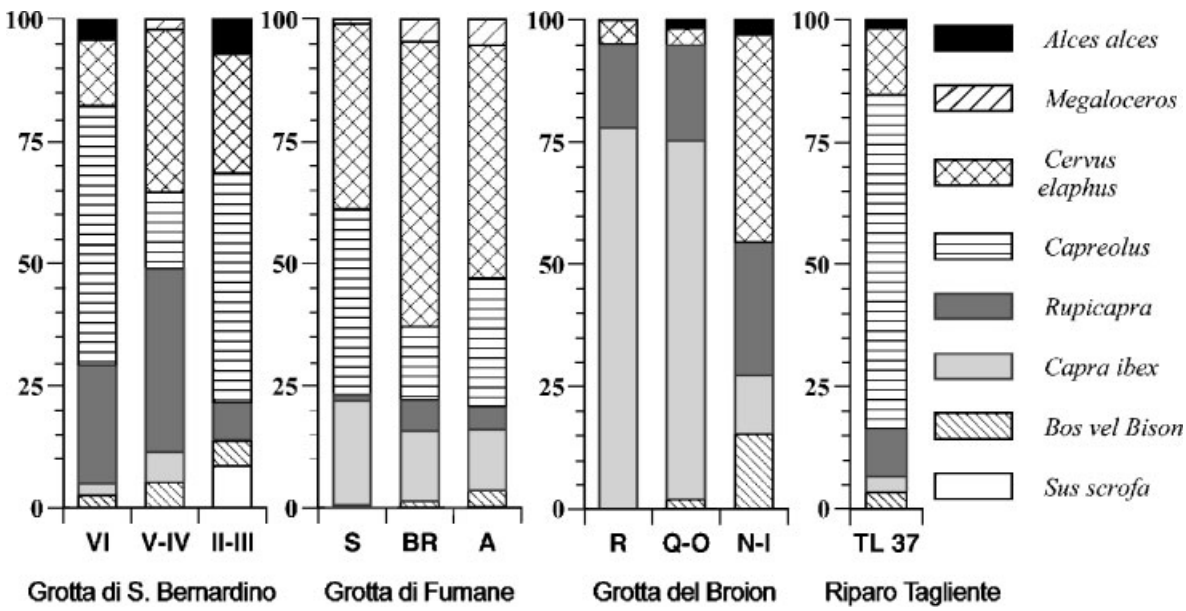

Figure 4. Frequency of the ungulates in some of the different sites considered in this paper. Grotta di San Bernardino (Cassoli & Tagliacozzo, 1994a); Grotta del Broion (Sala, 1980, 1990); Riparo Tagliente (Thun Hohenstein *et al.*, 2001); Grotta di Fumane (Cassoli & Tagliacozzo, 1994b and present work).

Table 3. Presence of the main mammal species in northeastern Italy during the Mousterian

Species	Presence
Red deer	Abundant. Absent only at Grotta della Ghiacciaia
Ibex	Abundant. Absent only at Riparo Mezzena
Bos/bison	Constant presence, few elements
Chamois	Less constant presence, some times considerable abundance
Roe deer	Less constant presence, some times considerable abundance
Giant deer, elk, wild boar	Less constant presence, few elements
Horse, rhinoceros and mammuthus	Very rare
Cave bear	Constant presence
Fox, wolf, mustelids and brown bear	Less constant presence
Hyena, lynx, leopard, lion and wild cat	More rare
Hare, marmot, beaver	Almost constant presence, few elements
Hystrix	Present only at Grotta di Fumane

Grotta della Ghiacciaia) and *Capra ibex* (absent at Riparo Mezzena). There is a constant presence of *Bos/Bison*, but with only few elements. *Rupicapra rupicapra* and *Capreolus capreolus* are not always present but are sometimes abundant. *Megaloceros giganteus*, *Alces alces*, and *Sus scrofa* are not constant, but they are represented by few elements. *Equus caballus*, *Mammuthus primigenius* and rhinoceros are always very rare. In Italy, ungulates are often used as indicators of climatic and environmental conditions. Their ecological meaning is shown in Table 4. Ecological reconstruction based on ungulates is influenced by human activity, however, such as hunting and butchering strategies, carcass transport, site function, and so on. Among the other mammals hare, marmot and beaver are an almost constant presence, but always with few elements. A specimen attributed to *Hystrix cristata* from Fumane represents the only discovery of this species, indicative of warm, temperate climates, for the glacial period in northern Italy. Among the carnivores, cave bear is always present (in some levels, caves were used as dens), fox, wolf, mustelids and brown bear are almost always present, while hyena, lynx, leopard, lion and wild cat are rarer. The presence, in some levels, of Asian microfauna typical of steppe environments and avifauna associated with arctic tundra indicates cold peaks during the last glaciation.

In northern Italy, during OIS 4 and OIS 3, the environment was mainly woodland (presence of numerous cervids, bear, carnivores) with temperate-cold climate. Some colder and drier periods and the diffusion of steppe and grassland habitats is indicated by the marked presence of ibex, chamois and marmot at low altitude, and the presence of steppe-dwelling micromammals and tundra-dwelling birds. The transition from the Mousterian to the Aurignacian coincides with a clear climatic and environmental shift towards an arid and cold climate, with prevalence of open habitat species.

Exploitation of animal resources

Modern archaeozoological data are available for three caves (Tagliente, S. Bernardino and Fumane). At other sites there are no data available on patterns of mortality, butchering marks, body part composition, role of carnivores, and so on. The analyses carried out to date indicate that hunted species were those most common in the specific environmental and climatic conditions (Figure 5). S. Bernardino and Fumane show a

Table 4. Ungulates used as indicators for climatic and environmental conditions in Italy

Species	Climate	Environment
Elk	Cold—humid	Marshy clearings
Ibex	Cold—arid	Rocky and alpine grasslands
Chamois	Cold—less arid	Alpine grasslands—steppe
Red and giant deer	Temperate—cold	Forests
Roe deer	Temperate	Woodlands and forests
Wild boar	Temperate—humid	Woodlands—humid clearings

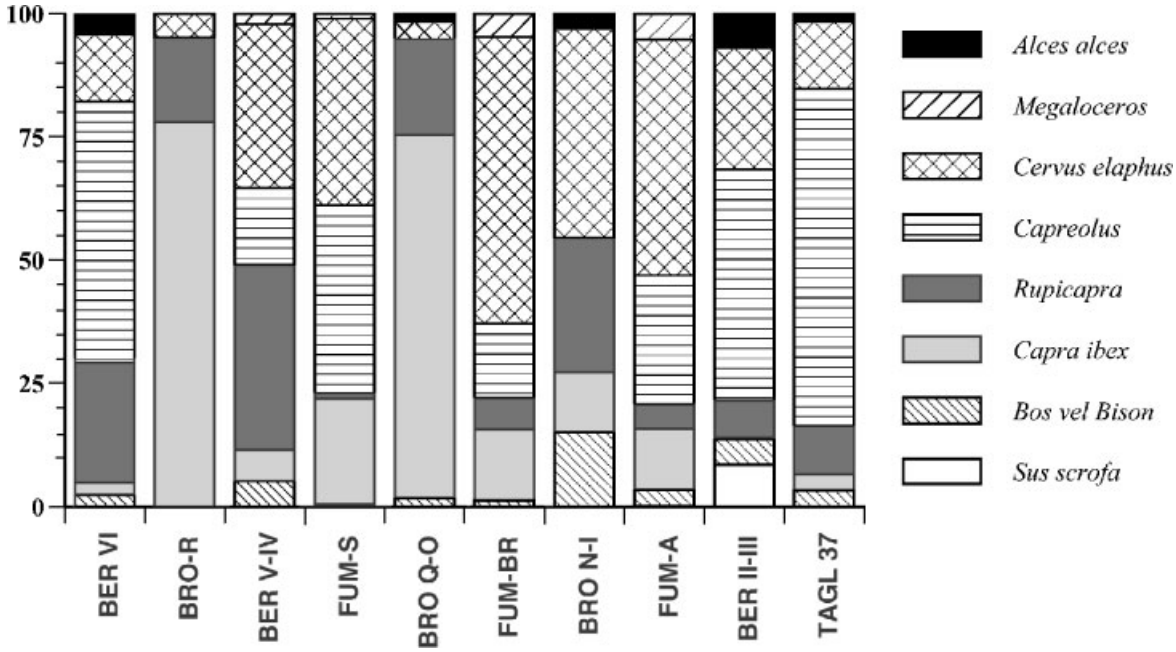

Figure 5. Seriation hypothesis of the different levels in the main sites.

similar ungulate exploitation model, while data from Broion are probably influenced by carnivore activity. For the ungulates, young adult and adult individuals were preferentially selected. At Grotta di Fumane complete ungulate carcasses (red deer, roe deer, ibex, chamois) were brought back to the site. The capture of hare, beaver, marmot and some carnivores (bear, fox, mustelids) is well documented and could indicate the recovery of pelts. The exploitation of birds is documented in a single instance (cut marks on an ungual phalanx of golden eagle), but it is possible that some species of Galliformes and Anseriformes were hunted. There are only scanty data relating to possible fishing activities.

There are no faunal data from the open air sites. If the mammoth remains and Mousterian artefacts at Pagnano d'Asolo are associated with one another, this would be the only butchering site of similar age in Italy. The thick stratigraphic sequences in the caves of the lower Monti Lessini and the Colli Berici suggest that these sites were reoccupied over long periods of time, and the wide range of activities that were carried out, including tool production and animal butchery, classifies them as residential camps.

Acknowledgements

This work was possible thanks to the fundamental help of P.F. Cassoli, who contributed to the activity of this Institution until his death in March 2003. Photographs were taken by D. Rosa at the photo laboratory of the Museo Nazionale Preistorico Etnografico 'L. Pigorini' of Rome. Thanks are due to F. Alhaique for the English translation. We thank the two anonymous referees, whose critical reviews improved this work and raised questions that enabled us to investigate previously overlooked aspects of our research.

References

Bartolomei G. 1960. Primi risultati delle ricerche sulla Grotta Maggiore di San Bernardino nei Colli Berici (Vicenza). *Annali dell'Università di Ferrara (N.S.)* **9**: 119–125.

Bartolomei G, Cattani L, Cremaschi M, Pasa A, Peretto C, Sartorelli A. 1980. Il Riparo Mezzena. *Memorie del Museo Civico di Storia Naturale di Verona* **2**: 1–69.

Bartolomei G, Broglio A, Cattani L, Cremaschi M, Guerreschi A, Mantovani E, Peretto C, Sala B. 1982. I depositi würmiani del Riparo Tagliente. *Annali dell'Università di Ferrara (N.S.)* **15**: 61–105.

Bartolomei G, Broglio A, Cattani L, Cremaschi M, Guerreschi A, Leonardi P, Peretto C. 1984. I giacimenti paleolitici e mesolitici. In *Il Veneto nell'antichità, preistoria e protostoria*, Aspes A (ed.). Banca Popolare di Verona: Verona; 169–319.

Broglio A. 2001. Discontinuity between the Mousterian and the Aurignacian: the archaeological sequence from the Grotta di Fumane in the Veneto Prealps. In *Jubilee Book Dedicated to Prof. J. K. Kozlowski*, Ginter B (ed.). Institute of Archaeology, Jagiellonian University: Krakow; 119–129.

Broglio A, Cremaschi M (eds). 1998–99. Studi sulla Grotta di Fumane. *Annuario Storico Della Valpolicella* **1998–1999**: 11–106.

Broglio A, Cremaschi M, Peresani M. 2002. La serie stratigrafica della Grotta di Fumane. *Memorie del Museo Civico di Storia Naturale di Verona (II serie), Scienze dell'Uomo* **5**: 12–14.

Cassoli PF, Tagliacozzo A. 1992. Analyse faunistiques: macromammifères et oiseaux. In Bartolomei G, Broglio A, Cassoli PF, Castelletti l, Cattani L, Cremaschi M, Giacobini G, Malerba G, Maspero A, Peresani M, Sartorelli A, Tagliacozzo A. La Grotte de Fumane. Un site aurignacien au pied des Alpes. *Preistoria Alpina* **28**: 137–148.

Cassoli PF, Tagliacozzo A. 1994a. I resti ossei di macromammiferi, uccelli e pesci della Grotta Maggiore di San Bernardino sui Colli Berici (VI): considerazioni paleoeconomiche, paleoecologiche e cronologiche. *Bullettino di Paletnologia Italiana* **85**: 1–71.

Cassoli PF, Tagliacozzo A. 1994b. Considerazioni paleontologiche, paleoecologiche e archeozoologiche sui macromammiferi e gli uccelli dei livelli del Pleistocene superiore del Riparo di Fumane (VR) scavi 1988–91. *Bollettino del Museo Civico di Storia Naturale di Verona* **23**: 85–117.

Dal Piaz G. 1931. Comunicazione sulla scoperta di selci paleolitiche nei Lessini. *Atti del Regio Istituto Veneto di Scienze, Lettere e Arti* **90**: 223–225.

Giacobini G. 1992. New discoveries of Palaeolithic humans remains in Italy. In *Cinq millions d'année, l'adventure humaine*, Toussaint M (ed.). ERAUL: Liege; 199–205.

Guerreschi A, Peretto C, Thun Hohenstein U. 2002. I depositi di Riparo Tagliente. *Memorie del Museo Civico di Storia Naturale di Verona (II serie), Scienze dell'Uomo* **5**: 15–18.

Leonardi P, Broglio A. 1961. Paleolitico superiore in situ nel deposito pleistocenico della Grotta di S. Bernardino nei colli Berici orientali (Vicenza). *Atti dell'Istituto Veneto di Scienze, Lettere ed Arti* **CXIX**: 435–450.

Malerba G, Giacobini G. 1995. Analisi delle tracce di macellazione in un sito paleolitico. L'esempio del Riparo di Fumane (Valpolicella, Verona). *Atti del 1° Convegno Nazionale di Archeozoologia. Padusa, Quaderni* **1**: 97–108.

Malerba G, Giacobini G. 1998. Les restes fauniques du Paléolithique moyen de la Grotte de San Bernardino (Vicenza, Italie nord-orientale): analyse micromorphologique des surfaces osseuses. In *Proceedings of the XIII Congress of the International Union of Prehistoric and Protohistoric Sciences*, 2, Facchini F, Palma di Cesnola A, Piperno M, Peretto C (eds). Abaco: Forlì 203–208.

Milliken S. 2001. The Neanderthals in Italy. *Accordia Research Papers (1999–2000)* **8**: 11–82.

Mourer-Chauviré C. 1975. Les oiseaux du Pléistocène moyen et supérieur de France. *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon* **64**(1–2): 1–624.

Palma di Cesnola A. 1961. Gli scavi nel Riparo Zampieri presso Verona. *Memorie del Museo Civico di Storia Naturale di Verona* **9**: 273–290.

Peresani M. 1995–1996. Sistemi tecnici di produzione litica nel Musteriano d'Italia. Studio tecnologico degli insiemi litici delle unità VI e II della Grotta di San Bernardino (Colli Berici, Veneto). *Rivista di Scienze Preistoriche* **XLVII**: 79–167.

Peresani M. 2001a. An overview of the middle palaeolithic settlement system in North-Eastern Italy. In *Settlement Dynamics of the Middle Palaeolithic and Middle Stone Age*, Conard NJ (ed.). Publications in Prehistory, Introductory Volume. Kerns Verlag: Tübingen; 485–506.

Peresani M. 2001b. The Middle Palaeolithic settlement system of the Eastern Italian Alps in ecological context. *Atti del XIII Congresso degli Antropologi Italiani. Rivista di antropologia* **78**(Suppl.): 19–23.

Peresani M, Sartorelli A. 1998. The lithic assemblages at the Cave of Fumane. New evidence of technological variability in the Middle Palaeolithic of Northern Italy. In *Proceedings of the XIII Congress of the International Union of Prehistoric and Protohistoric Sciences*, 2, Facchini F, Palma di Cesnola A, Piperno M, and Peretto C (eds). Abaco: Forlì; 269–278.

Peresani M, Bertola S, Peretto C, Thun Hohenstein U. 2001. Paleoecological and paleoeconomics aspects of the Middle Palaeolithic site of the Ghiacciaia Cave (Venetian PreAlps). *Atti del XIII Congresso degli Antropologi Italiani. Rivista di antropologia* **78**(Suppl.): 3–7.

Peresani M, Tagliacozzo A. 2002. La sequenza musteriana della Grotta di Fumane. Preistoria Veronese. Contributi e aggiornamenti. *Memorie del Museo Civico*

di Storia Naturale di Verona (II serie), Scienze dell'Uomo **5**: 22–24.

Peretto C. 1992. Il Paleolitico Medio. In *Italia Preistorica*, Guidi A, Piperno M (eds). Laterza: Bari; 170–197.

Peretto C, Thun Hohenstein U. 2002. Riparo Tagliente. *Memorie del Museo Civico di Storia Naturale di Verona (II serie), Scienze dell'Uomo* **5**: 24–25.

Reggiani P, Sala B. 1992. I Mammut del veneto. *Memorie di Scienze Geologiche* **XLIV**: 171–191.

Sala B. 1980. Interpretazione crono-bio-stratigrafica dei depositi pleistocenici della Grotta del Broion (Vicenza). *Geografia Fisica e Dinamica Quaternaria* **3**: 66–71.

Sala B. 1990. Loess fauna in deposits of shelters and caves in the Veneto region and examples in other region of Italy. In *The Loess in Northern and Central Italy: A Loess Basin Between the Alps and the Mediterranean Region*, Cremaschi M (ed.). Quaderni di geodinamica alpina e quaternaria. CNR Centro per la Stratigrafia e la Petrografia delle Alpi Centrali: Milano; 139–149.

Thun Hohenstein U, Malerba G, Giacobini G, Peretto C. 2001. New contribution to the taphonomic analysis of the faunal remains from the Mousterian levels of Riparo Tagliente (Verona). *Atti del XIII Congresso degli Antropologi Italiani. Rivista di Antropologia* **78**(Suppl.): 39–44.

Villa G, Giacobini G, Peretto C, Thun Hohenstein U. 2001. Neanderthal teeth from the Mousterian levels of the Riparo Tagliente (Verona, NE Italy). *Atti del XIII Congresso degli Antropologi Italiani. Rivista di antropologia* **78**(Suppl.): 45–49.

