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MORPHOMETRY OF THE *URSUS SPELAEUS* REMAINS FROM VALSTRONA (NORTHERN ITALY)

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With 14 figures and 2 plates

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Abstract

Morphometric analyses on cave bear fossils of the Valstrona-Valsesia region (Piedmont, Northern Italy) (in particular from the Delle Streghe Cave), allow the distinction of at least two or three populations of *Ursus spelaeus* Rosenmüller, 1794, of different sizes. Elements of smaller size are likely to be found in the Buco dell'Orso Cave (Laglio, Como province, Lombardy), and in the older strata of the Grotta Sopra Fontana Marella –GSFM- (Varese province). Differences in size can be linked to the chronological position of the fossils studied: in fact, fossils of smaller dimensions should be chronologically older, but can also be linked to climatic and thermoregulation factors. The increase of size could represent a response to a cooler climate. An alternative hypothesis associates this reduction of size to the cooler climatic shift. Observations on the Delle Streghe Cave fossils indicate that they are very similar to those inferred for the GSFM population, linking this trend to climatic variation. The reason for an increase in size could also be linked to the rapid evolution of the cave bears and the Delle Streghe fossils should cover a chronological range approximately similar to the fossils from GSFM.

Introduction

During the Late Pleistocene *Ursus spelaeus* Rosenmüller, 1794 (Rosendhal & Kempe, 2004) colonized a large part of Europe, migrating to the south (central Italy), towards the west (Spain), and towards the north-west (Great Britain) exhibiting the most numerous morphological and morphometrical varieties. Several studies concerning the cave bear group, *Ursus spelaeus* and its ancestor *Ursus deningeri* Von Reichenau, 1906 and *U. arctos* species coeval to *U. spelaeus* (Rabeder, 1999; Weinstock, 1999; Perego et al., 2001; Rossi & Santi, 2001 a, b; Santi & Rossi, 2001; Santi et al., 2003 and others) have allowed several hypotheses to be advanced about the relationships between cave bears, *U. deningeri* and coeval species, and about possible phyletic lines indicated by the fossiliferous record and by recent mtDNA examination (Hofreiter et al., 2002, 2004). Currently, radiometric data is only available for a few caves in Northern Italy: the best known example is the Grotta Sopra Fontana Marella (Varese Province, Lombardy). For the other caves (i.e. the Caverna Generosa, Varese Province) the data are still incomplete (Bona, 2004). Radiometric data and aminoacid racemization of the bear bones from Grotta Sopra Fontana Marella provide the following ages: sample FM4 over 26000 years BP, FM2, 22310 ±200 years BP and FM1 21810±200 years BP (Perego et al., 2001). The wealth of discoveries in various caves in Northern Italy have shed new light on the distribution of the

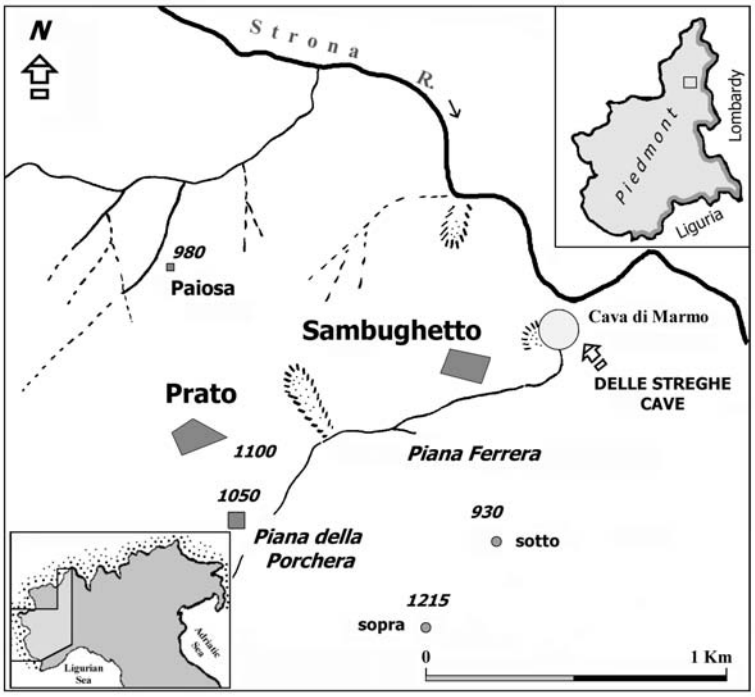


Fig. 1: Geographic position of the Delle Streghe Cave (Valstrona, Piedmont, Northern Italy).

vertebrates in this area. In some zones research has only just started; one such example is the Valsesia-Valstrona (Piedmont) area (Fig. 1). The aim of this paper is to summarize previous results regarding these cave bear populations.

Geographical-geological frame of the studied area

Valstrona is a narrow valley with a V-shaped profile in its lower reaches while at its head, near Cima di Capezzone-Punta del Pizzo (2240 m)-Punta d'Issola (2146 m), it enlarges into a wide cirque. It winds for 20 km to Omegna village where it debouches onto the Orta Lake (Cusio). Near the Sambughetto village some caves have formed via karst processes within the lens of the "Marmo Valstrona" formation; this lenticular body is intercalated between gneisses and micaschists of the "Serie Kinzigitico-sillimanitica". Inside the caves the osteological material, accompanied by yellow loessic clay, collects in the lower parts along the side lanes and cavities. This sediment is frequently covered by hard stalagmitic soil (about 15-20 cm thick), and by grey micaceous and sterile sands interspersed with smaller gravel of more recent age linked to the pluvial washing away phase. To ensure good preservation of bones, deposits were only slightly disturbed and analysed *in situ*.

Fossils from Valstrona have been found inside the caves known as Complesso dell'Intaglio and Caverna delle Streghe, near the Cava Sambughetto village. The first of these caves opens out in the upper part of the marble quarry ("Sass Muiè"), it has five entrances and a subcircular small gallery complex correlated with an older level of the water-bearing stratum. The second cave, called Caverna delle Streghe, is the widest cave in Verbania Province. It is composed of a fossil branch presently foliated by water and by a second active branch in the marble eroded by the river (Fig. 2). The water source is from the Chignolo stream that, after having crossed the cave and swelled water from other tributaries, re-emerges in the Strona River.

The Valsesia fossils are derived from the Mt. Fenera (Fig. 3) caves and mainly from the "Ciutarun" and the "Ciota Ciara" cave. The former is situated at 650 m asl, with a large ogival entrance, and it is 55 m long and up to 13 m high. The "Ciota Ciara" is located at an altitude of 685 m asl, it is 57 m long and the difference in levels internally is up to 18 m. There are two entrances: a southern, natural and a northwestern entrance which was formed by the collapse of a part of the vault. This cave rises upward from SE-NW and ends towards the N (Strobino, 1981).

Materials and methods

About one thousand *Ursus* remains currently stored in the Museo Civico di Storia Naturale di Milano have been analysed. They have been labelled "**MCSNM V**", (abbrevation of **M**useo **C**ivico di **S**toria **N**aturale and **V**ertebrate), followed by a progressive number. A substantial portion of the skeletons of cubs, juveniles and adult elements is represented (Pls. 1-2). The material is rarely complete, especially the skull remains, and in particular in the case of cubs only skull-caps have been preserved. Preservation is generally good, although some

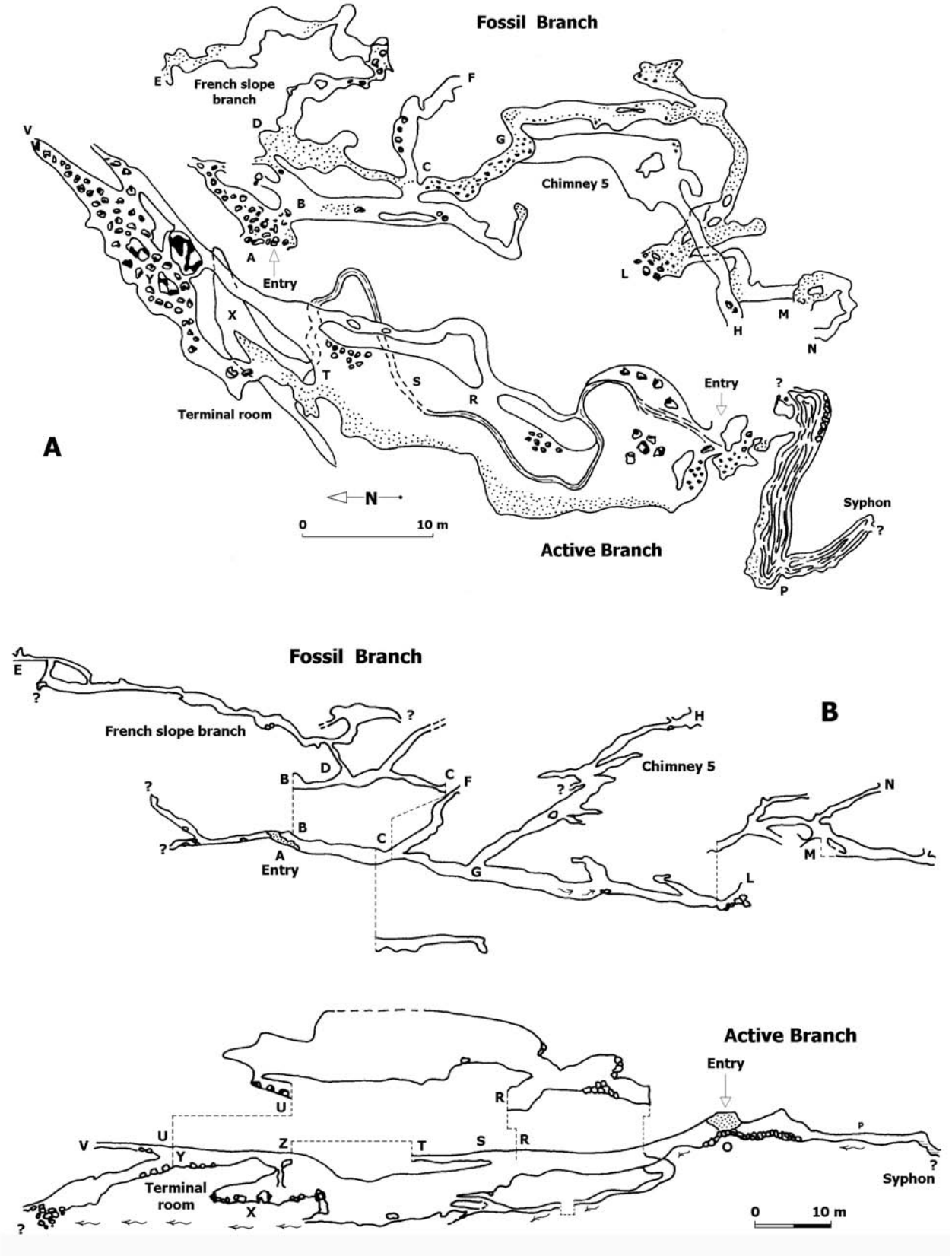


Fig. 2: A – Planimetric scheme and profiles; B – of the Delle Streghe Cave (Cella, 1993, mod.).

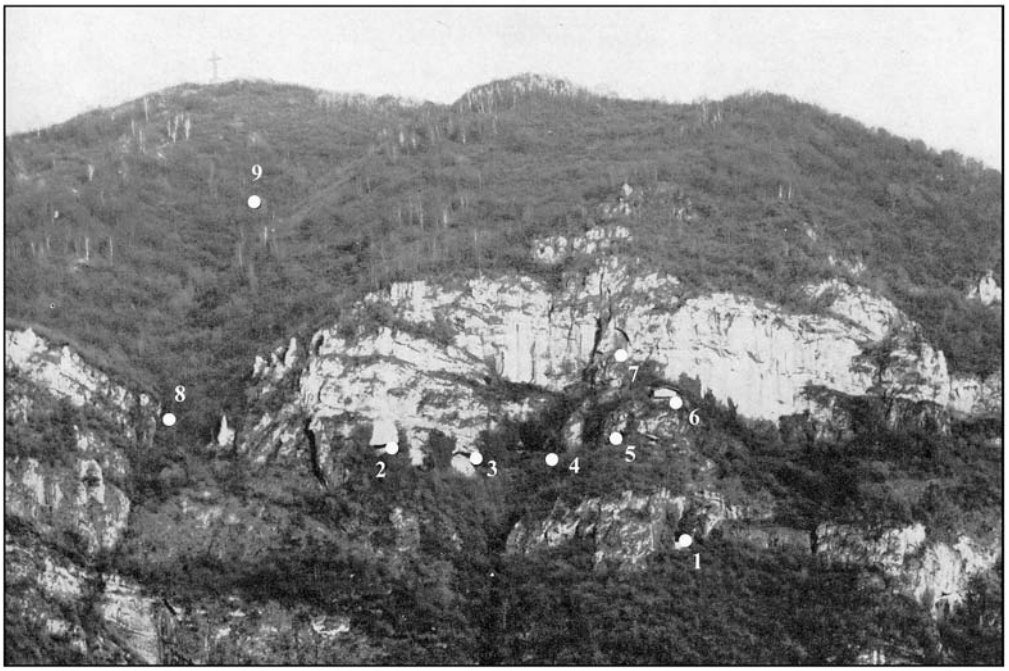


Fig. 3: Distribution of the main caves in the Fenera Mt. (Valsesia, Piedmont, Northern Italy). Number 1 is the "Ciutarun", 2 and 3 refer to the "Ciota Ciara". (Strobino, 1981, mod.).

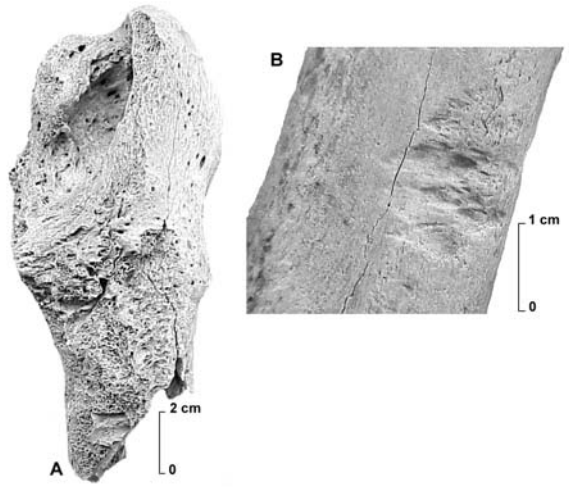


Fig. 4: **A.** Pathological *Ursus* bone (specimen MSNM V 4362, Delle Streghe Cave). **B.** Predatory activity traces (specimen MSNM V 4097, Delle Streghe Cave).

traces of erosion can be found in the proximal and distal ends of limb bones. In addition, some specimens showed traces of pathologies (e.g. periarthritis and pesudoarthrosis) and generic malformations, traces of predator activities (Fig. 4). The presence of predators is indicated by the catlike remains inside the Delle Streghe fauna with an incomplete right radius fragment (MSNM V4329) belonging to *Panthera leo spelaea* (Goldfuss, 1810) (Fig. 5). Most of the fossils belong to *Ursus spelaeus* Rosenmüller, 1794, while others with disputed morphological features could be classified as *Ursus deningeri* Von Reichenau 1906. However we have considered these remains as *U. spelaeus* on the basis of the broader morphological relationships within this species. Useful morphometric parameters were deduced from Hue (1908), Von den Driesch (1976) and Torres (1988).

Morphometry

SKULL – These fossils, although incomplete, have some morphometric features that seem to be typical of cave bears. They are generally similar in size to examples of *U. spelaeus* from caves in Spain and slightly larger than those from Caverna delle Ossa (Zandobbio, Bergamo Province, North of Milan).

MANDIBLE – The relationship between the transversal diameter of the condyle and the vertical diameter (Fig. 6) confirms what has been inferred regarding skull morphometric analysis. The Sambughetto specimens are similar in size to the typical *spelaeus* (in this paper represented by fossils

from Covoli di Velo Veronese, Verona Province), but they are larger than those from the Buco dell'Orso cave, whose small sizes can be linked to climatic factors (Bergmann's rule). The dimensions of the mandibular condyle, but especially the height of the mandible below P_4, provided additional evidence supporting what has been deduced from skull analysis. Comparison between the fossils studied and samples from some Venetia caves (Grotta del Cerè whose population appears to be older, Covoli di Velo Veronese and S. Donà di Lamon) and from Grotta Sopra Fontana Marella –GSFM- (Varese Province, Lombardy), allows us to place the Delle Streghe bears in an intermediate position between ancient and modern forms. These data are also supported by dental surface features. Data referred to the M1 and M2 show the greatest range compared to those of the other specimens considered (Pocala, Equi, GSFM, Covoli di Velo, Buco dell'Orso, Caverna delle Fate, Grotta delle Ossa) and a smaller length/width ratio. This feature could be probably related to local factors and particularly to food preferences. But we cannot exclude that this difference in size may be related to sexual dimorphism.

HUMERUS – As shown in diagram Fig. 7, the Delle Streghe specimens show similar features to those from GSFM. In fact, the absolute dimensions are similar. The main difference is evident from the greater deformation of the diaphyses of the analysed remains, and particularly in the more recent forms due to a smaller antero-posterior diameter.

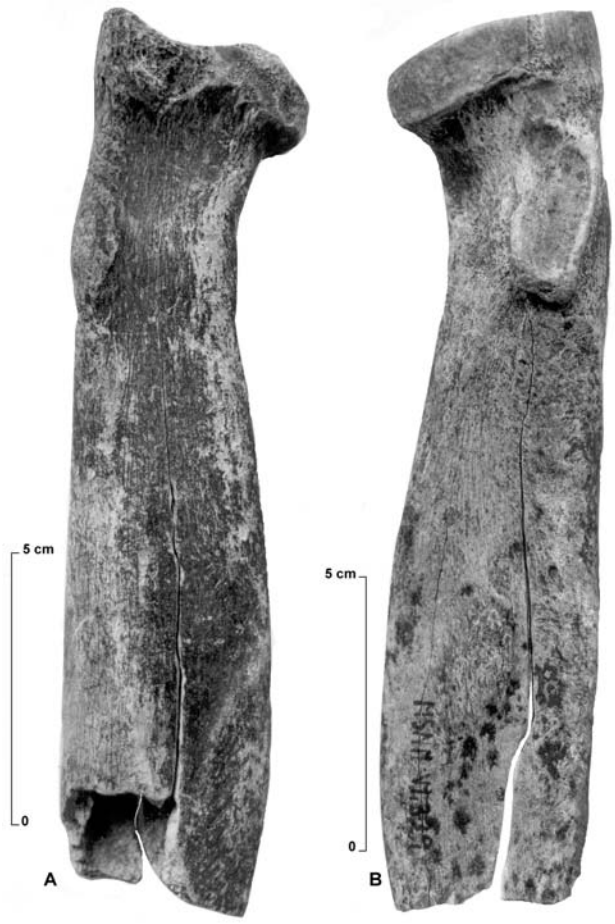


Fig. 5: *Panthera leo spelaea* (Goldfuss, 1810). Specimen MSNM V 4329 (Delle Streghe Cave). Right radius. **A**: External view, **B** – Internal view.

RADIUS – Data concerning the radius seem to confirm what is shown by the humeri. In particular some morphometric relationships (Fig. 8) allow us to affirm that: a) the morphometric characteristics of the specimens studied are comparable with those of the GSFM, b) generally, adult elements can be compared with those from the older and intermediate levels of the GSFM, while the

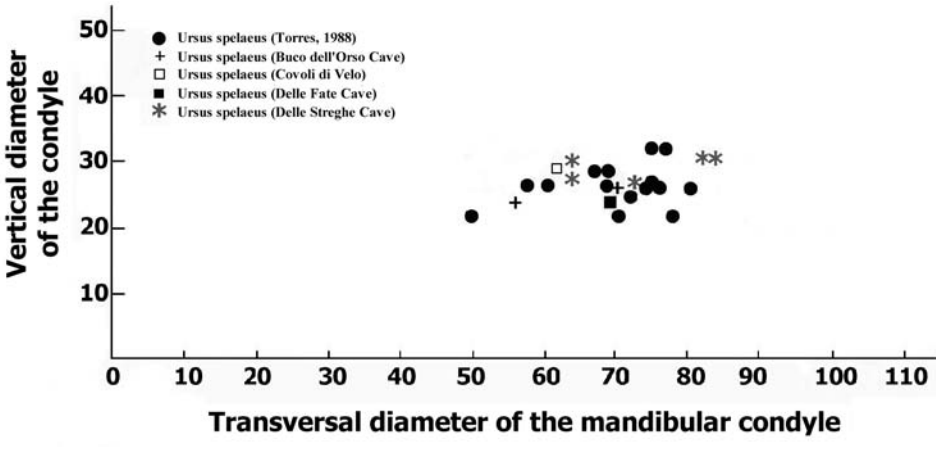


Fig. 6: Relationship between *Transversal Diameter of the condyle* and *Vertical diameter* in mandibles of *Ursus spelaeus* from c

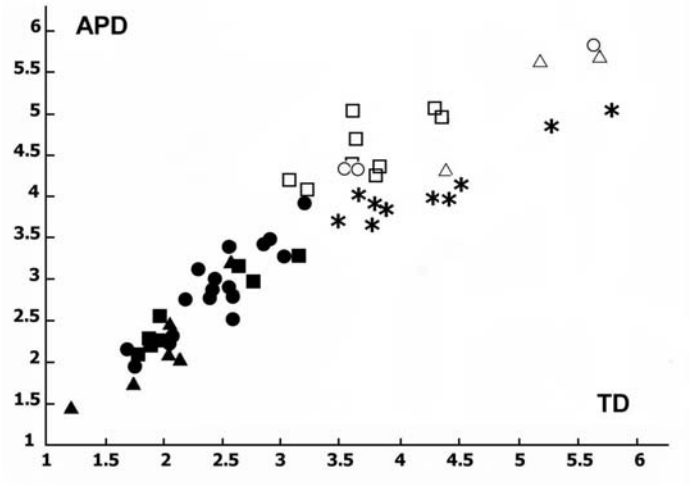


Fig. 7: *Antero-posterior diameter of the diaphysis* (ordinate) and *Transversal diameter of the diaphysis* (abscissa) relationship in the humeri of the *Ursus spelaeus* from Delle Streghe and Grotta Sopra Fontana Marella (GSFM) caves. Symbol legend: ✱ Delle Streghe specimens. Grotta Sopra Fontana Marella specimens: ▲ juveniles from FM2, ● juveniles from FM1, ■ juveniles from FM4, Δ adults from FM2, O adults from FM1, □ adults from FM4 and FM2 (Perego et al., 2001 mod.).

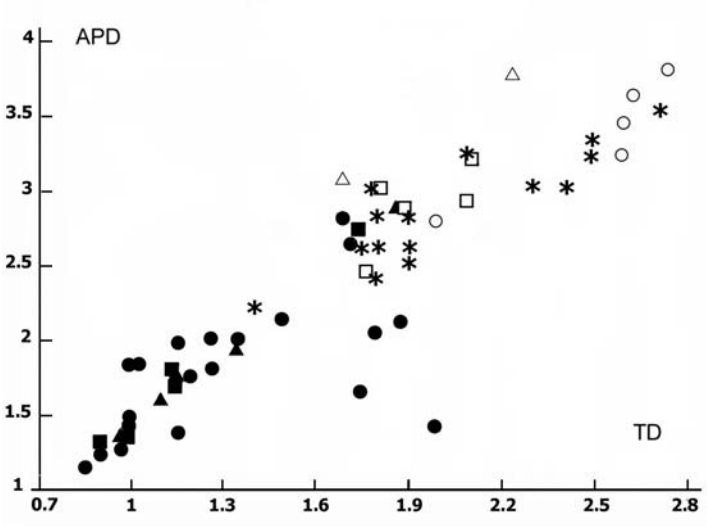


Fig. 8: *Antero-posterior diameter of the diaphysis* (ordinate) and *Transversal diameter of the diaphysis* (abscissa) relationship in the radii of the *Ursus spelaeus* from Delle Streghe and Grotta Sopra Fontana Marella (GSFM) caves. Asterisks represent the Delle Streghe specimens, for the legend of the other symbols see Fig. 7 (Perego et al., 2001 mod.).

younger elements cover the whole time interval, c) some remains display dimensions similar to the largest among the more recent GSFM forms. Such an irregular distribution may depend on: 1) sexual dimorphism, 2) the presence of elements related to different evolutionary stages (the smaller sized specimens being older, while the larger ones are more recent), 3) climatic factors.

Similar conclusions can be advanced for the ulnae as well.

PISIFORM – Morphometric data referring to pisiform (Fig. 9) have allowed us to distinguish three clear size ranges: 1) a group with forms comparable to the *U. deningeri* and *U. arctos* species from caves in Spain; 2) a second group with elements comparable to the *U. spelaeus* (smaller sized) from the Buco dell'Orso cave (Laglio, Como province, Lombardy) but more massive, and: 3) a third group with large elements. The hypothesis that *U. spelaeus* corresponded to the smaller elements is based on the clear speloid morphology (see Torres, 1988) but they could also be females or juvenile forms, or related to a cooler climatic phase (Gerhard, 2001). It is more likely that they would be female specimens because the points are close to those from the Buco dell'Orso Cave that are indisputably adult forms (Santi et al., 2003). The presence of one group of adult medium- to-small sized elements with another group having medium dimensions is very interesting. In fact, the lack of intermediate forms can be simply related to the quantity of useful data, but also to the actual presence of two separate populations.

METACARPUS – The morphometric features of the studied remains (Fig. 10a) are very similar to those from the Buco dell'Orso cave (clearly *spelaeus*). They are of smaller size than the typical *spelaeus*. When compared with the data from the literature (Di Canzio & Petronio, 2001; Santi et al., 2003), one can conclude that a female element is probably present among the II° metacarpus specimens. The diagram relating to the V° metacarpus (Fig. 10b) shows that three elements are more massive than the others used for comparison. These different morphometric features could depend on dimorphic character or different evolutionary phases.

FEMUR AND TIBIAE - Morphometric data (Fig. 11) show similar features to adult elements from the GSFM and the Buco dell'Orso cave. Compared with the GSFM, the studied remains appear to correspond to the temporal arch also covered by the compared fossils. It is therefore possible that they

Fig. 9: Distribution points of the *greatest length* and *greatest width* ratio in the pisiforms of different *Ursus* species from caves in Italy and Spain (Santi et al., 2003 mod.).

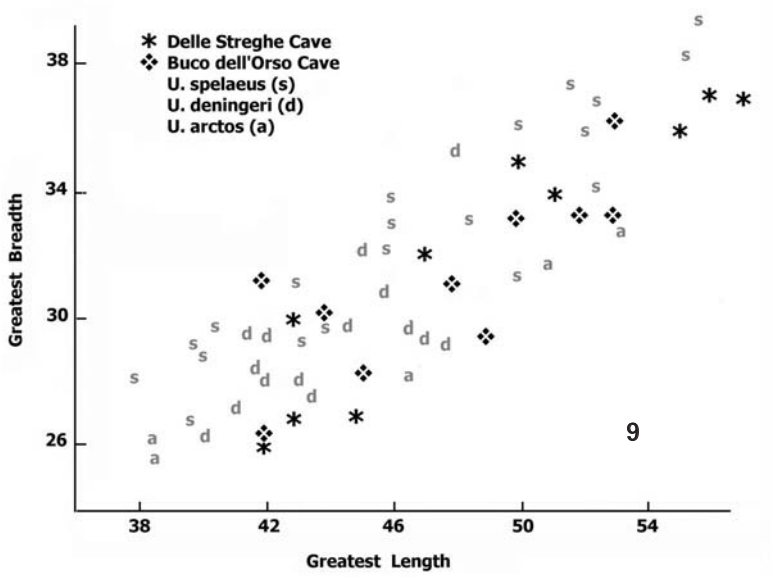
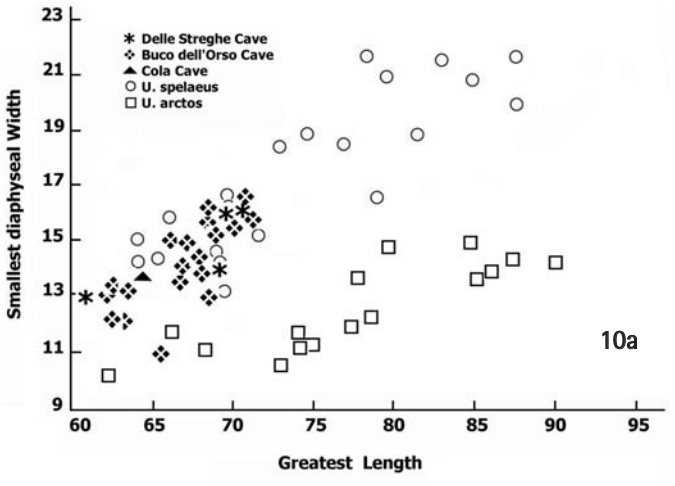
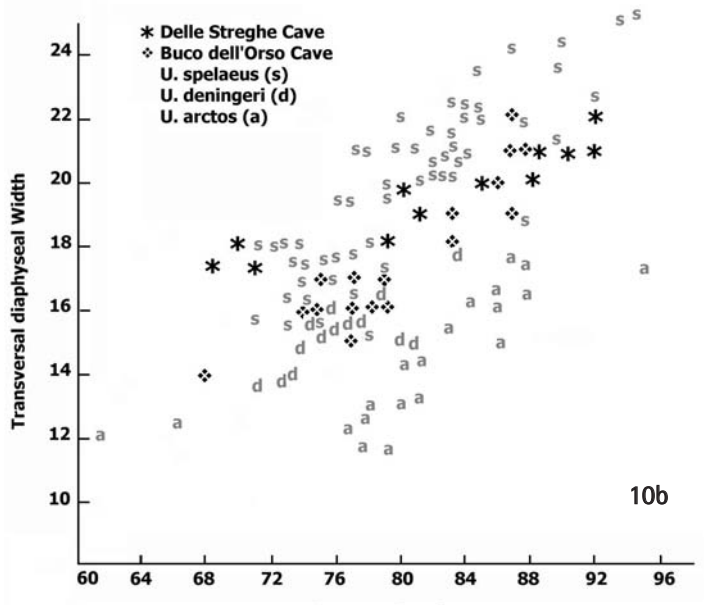


Fig. 10: **a**. Distribution points of the *greatest length* and the *smallest diaphyseal width* ratio in the II metacarpus of different *Ursus* species from caves in Italy and Spain . **b**. Distribution points of the *greatest length* and the *transversal diaphyseal width* ratio in the V metacarpus of different *Ursus* species from caves in Italy and Spain (Santi et al., 2003 mod.).





may represent different evolutionary steps within the same population. Fig. 11 also shows the presence of a juvenile element. Similar conclusions are also advanced for the tibiae in comparison with the GSFM and Buco dell'Orso populations.

ASTRAGALUS, SCAPHOID AND METATARSUS – Analogous to proposals for other parts of the skeleton, data concerning the astragalus (Fig. 12) show more deformed bones than those used for comparison (Buco dell'Orso). The paucity of data inhibits a profound analysis of the scaphoids; nevertheless initial analysis seems to confirm observations also advanced for the astragalus. In addition, morphometric data concerning the III metatarsus (Fig. 13) confirm that they belong to the *U. spelaeus*. Their small size probably indicates the presence of females.

PHALANGES – Generally, the data show morphometric features similar to the Buco dell'Orso bears. The distribution of the points relating to the II phalanx (Fig. 14) shows two clear clouds possibly due to dimorphism.

Concluding remarks

The discovery of an incomplete radius of *Panthera leo spelaea* (Goldfuss, 1810) next to *Ursus* specimens, widens the faunistic association of the Delle Streghe cave to

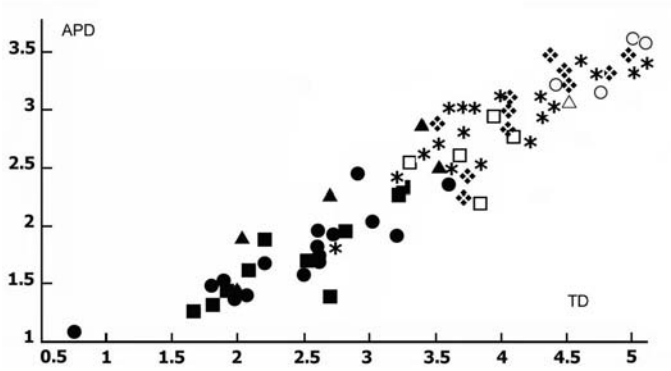


Fig. 11: *Antero-posterior diameter of the diaphysis* (ordinate) and *Transversal diameter of the diaphysis* (abscissa) ratio in the femurs of *Ursus spelaeus* from Delle Streghe and Grotta Sopra Fontana Marella caves. Asterisks indicate the Delle Streghe specimens, for the legend of the other symbols see Fig. 7 (Perego et al., 2001 mod.).

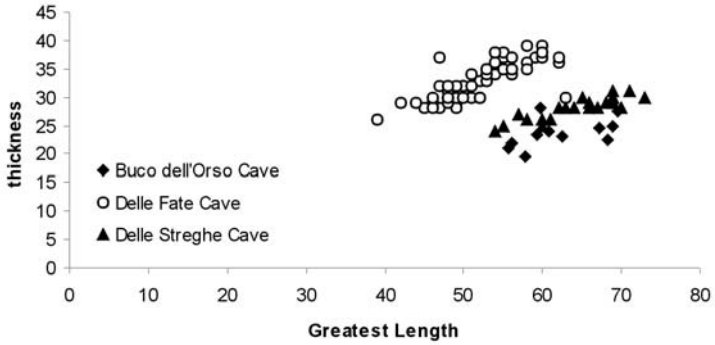


Fig. 12: *Greatest length* and the *thickness* relationship in the astragali of *Ursus spelaeus* from caves in Italy.

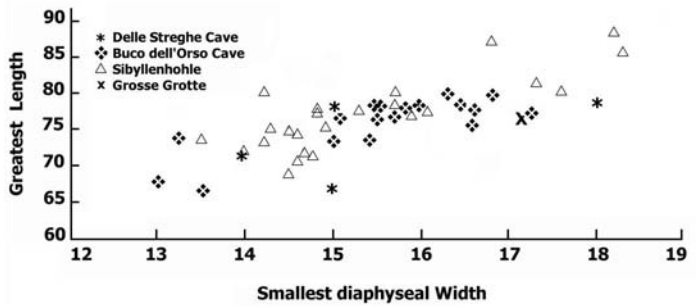


Fig. 13: *Smallest diaphyseal width* and the *greatest length* ratio in the III metatarsus of *Ursus spelaeus* from caves in Italy and Germany (Santi et al., 2003 mod.).

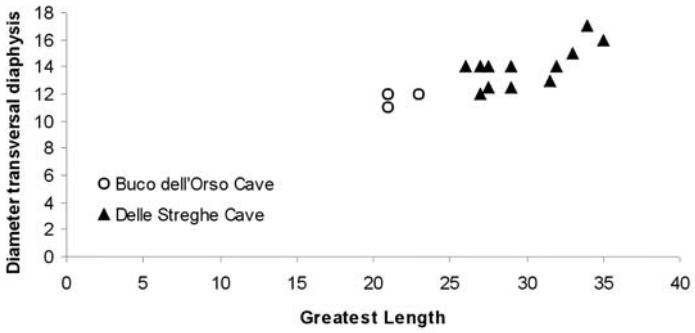


Fig. 14: *Greatest length* and the *diameter transversal diaphysis* relationship in the II phalanx of *Ursus spelaeus* from caves in Italy.

other nearby caves (Buco dell'Orso Cave, Delle Ossa Cave – Zandobbio in Bergamo Province). Pathologies are rare, mainly confined to limbs, and related to the senescence of the bears. Morphometric data indicate the presence of at least two populations of cave bears characterized by different sizes: the small-size bears are comparable to the Buco dell'Orso cave bears and those specimens from the older levels to the Grotta Sopra Fontana Marella. According to Perego et al. (2001), the difference in size is related to a different evolutionary step of the bear; small size could correspond to more ancient forms, namely more primitive ones. The increase in size can be linked to a thermoregulation factor following Bergmann's rule (1847): the increase in body size yields an advantage in thermoregulation. Loss of heat in bodies of large size is lower, causing a smaller surface-to-volume ratio. In this manner large sized populations can colonize cool regions. Moreover, in the case of the studied bears, an increase in dimensions could also represent a response to a shift towards a cooler climate. In contrast to these authors, Gerhard (2001) and Rabeder & Nagel (2001) associate a similar reduction in size to the shift toward cooler conditions although this should be observable in high Alpine regions. The similarity between the Grotta Sopra Fontana Marella and Delle Streghe Cave fossils leads us to link this trend to a climatic change, rather than to rapid evolution by cave bears.

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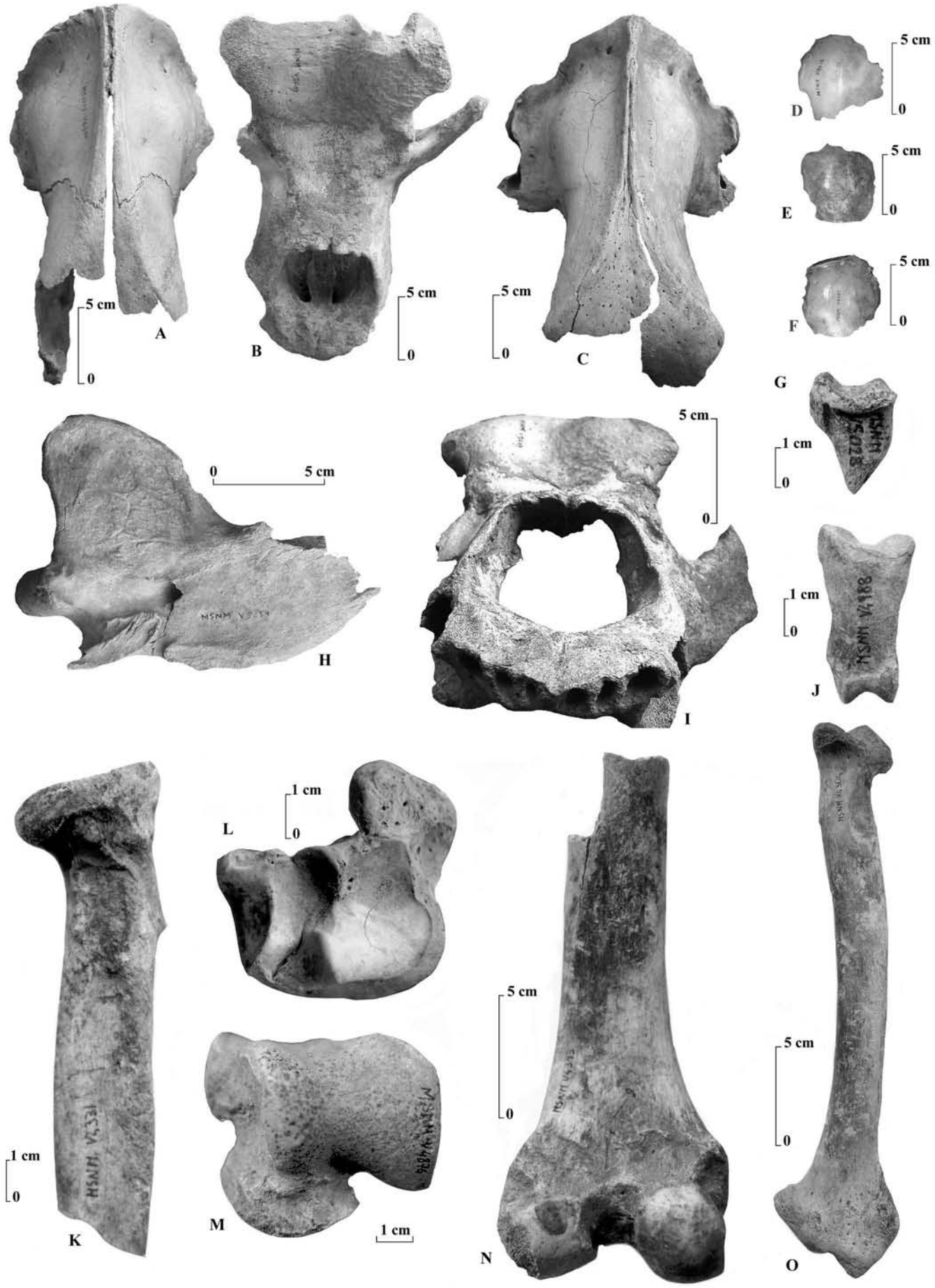
Plate 1: *Ursus spelaeus* Rosenmüller, 1794. Delle Streghe Cave (Sambughetto Valstrona, Piedmont, North Italy). **A** – Skull. Specimen MSNM V 4486, dorsal view. **B** – Skull. Specimen MSNM V 5043, dorsal view. **C** – Skull. Specimen MSNM V 5041, dorsal view. **D** – Skull-cap of cub. Specimen MSNM V 4614, dorsal view. **E** – Skull-cap of cub. Specimen MSNM V 4736, dorsal view. **F** – Skull-cap of cub. Specimen MSNM V 4721, dorsal view. **G** - III phalanx. Specimen MSNM V 5028, lateral view. **H** – Mandible. Specimen MSNM V 5059, internal view. **I** - Skull. Specimen MSNM V 5043, frontal view. **J** – I phalanx. Specimen MSNM V 4988, dorsal view. **K** – Radius. Specimen MSNM V 4331, external view. **L** – Scapholunar. Specimen MSNM 4781, lateral view. **M** – Astragalus. Specimen MSNM 4874, dorsal view. **N** – Femur. Specimen MSNM V 4393, caudal view. **O** – Radius. Specimen MSNM V 4304, dorsal view.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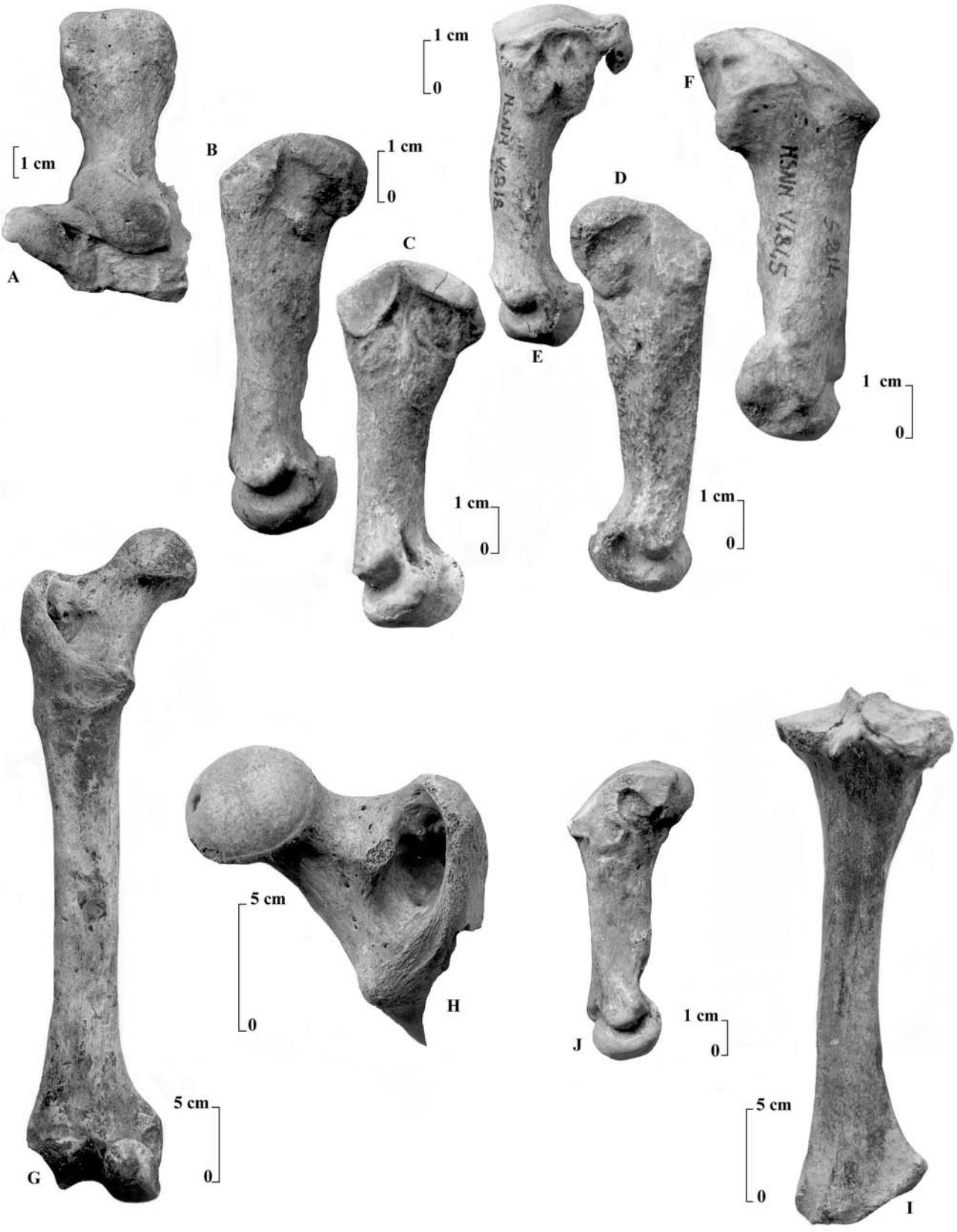

Plate 2: *Ursus spelaeus* Rosenmüller, 1794. Delle Streghe Cave (Sambughetto Valstrona, Piedmont, North Italy). **A** - Calcaneus. Specimen MSNM V 4904, dorsal view. **B** - IV° metacarpus. Specimen MSNM V 4827, medial view. **C** – III° metacarpus. Specimen MSNM V 4824, medial view. **D** – IV° metacarpus. Specimen MSNM V 4828, medial view. **E** – II° metacarpus. – V° metacarpus. Specimen MSNM V 4845, lateral view.