THE MIDDLE-LATE PLEISTOCENE MAMMAL FAUNA FROM MONTIGNOSO (LEGHORN, CENTRAL ITALY)

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ABSTRACT - *The Middle-Late Pleistocene mammal fauna from Montignoso (Leghorn, central Italy)* - A historical collection of fossil mammals from Montignoso (Leghorn, central Italy) is revisited here. The faunal community is fairly diversified; it includes *Elephas (Palaeoloxodon) antiquus, Equus ferus, Stephanorhinus hemitoechus, Sus scrofa, Hippopotamus* sp., *Cervus elaphus, Dama dama, Capreolus capreolus, Bos primigenius, Bison* sp., *Canis lupus, Vulpes vulpes, Lynx* sp., *Felis silvestris, Panthera pardus, Crocuta crocuta, Ursus arctos, Marmota marmota, Hystrix* sp., *Arvicola cantiana-terrestris, Aquila* sp. and *Aves* indet. Taphonomic analyses lead to the conclusion that the Montignoso assemblage consists in a time-averaged attritional accumulation of mammal remains reworked from a nearby land surface. From the stratigraphic viewpoint, the porcupine is a small-sized representative which is perhaps referable to *Hystrix vinogradovi*, a species characteristic of the last interglacial. An attribution of this fauna to the Eemian is apparently consistent with the presence of a water vole transitional between *A. cantiana* and *A. terrestris*.

RIASSUNTO - *La fauna a mammiferi del Pleistocene medio-superiore di Montignoso (Livorno, Italia centrale)* - Viene revisionata una storica collezione di mammiferi fossili di Montignoso (Livorno, Italia centrale). La comunità faunistica è abbastanza diversificata; essa comprende *Elephas (Palaeoloxodon) antiquus, Equus ferus, Stephanorhinus hemitoechus, Sus scrofa, Hippopotamus* sp., *Cervus elaphus, Dama dama, Capreolus capreolus, Bos primigenius, Bison* sp., *Canis lupus, Vulpes vulpes, Lynx* sp., *Felis silvestris, Panthera pardus, Crocuta crocuta, Ursus arctos, Marmota marmota, Hystrix* sp., *Arvicola cantiana-terrestris, Aquila* sp. and *Aves* indet. Analisi tafonomiche portano a concludere che l'associazione di Montignoso consista in un accumulo di resti di mammiferi formatosi durante un certo intervallo di tempo in una piana vicina e da lì rimaneggiati. Dal punto di vista stratigrafico, l'istrice è rappresentata da una forma di piccola taglia, probabilmente riferibile a *Hystrix vinogradovi*, una specie caratteristica dell'ultimo interglaciale. Una attribuzione di questa fauna all'Eemiano è apparentemente coerente con la presenza di una forma di topo d'acqua transizionale fra *A. cantiana* e *A. terrestris*.

1. HISTORICAL

The first excavations at Montignoso were performed during the second half of the last century. The site is located at the southeastern outskirt of Leghorn along the valley of the Rio Ardenza (Fig. 1). The area is characterized by the occurrence of a number of joints that cut their way through the Acquabona Formation, an Upper Miocene biocalcarenite (Fig. 2). The bone-bearing fissures were partially infilled with Quaternary "panchina" sediments. One of these fissures, called Buca delle Fate, was accidentally discovered exploiting a lime-pit and was destroyed by further escavations shortly later. The site consisted in a narrow joint, trending E-W, infilled with human and domestic animal remains, pottery and Eneolithic industries; historical age residues were found at the very top of the sequence. Another group of fissures, trending S-N or SW-NE, provided a rich collection of Middle-Late Pleistocene mammal bones.

The joints were found, escavated and first studied by Cocchi (1865), who provided an accurate description of the geological setting of the area and of the nature and characters of the infilling sediments. The Author mainly concentrated on the finds from Buca delle Fate.

Many following studies were mostly aimed to the analysis of the human bones and of the lithic implements (Cocchi, 1871; Colini, 1898; Sergi, 1908; Grifoni Cremonesi, 1971). Only Del Campana (1909) gave a full description of the faunal elements found in the other fissures, those which provided Pleistocene mammal remains, though without specifying the exact level of provenance.

2. METHODS

The nature of the infilling imposed a careful taphonomic investigation. Particular attention was addressed to any possible evidence of transportation, exposure to weathering, scrape marks or fracturing for marrow extraction, all characters that can provide useful paleoecological information.

The multivariate approach proposed by Behrensmeyer (1991) was followed here in order to tentatively reconstruct the taphonomic history of the fossil bone accumulation. The methodology includes a threefold series of observations: assemblage data, general characters of the accumulation and taphonomic evidence. The qualitative and quantitative variables are plotted on a diagram, which is finally compared with selected hypothetical accumulations from recent systems in order to assess the factors responsible for the accumulation.
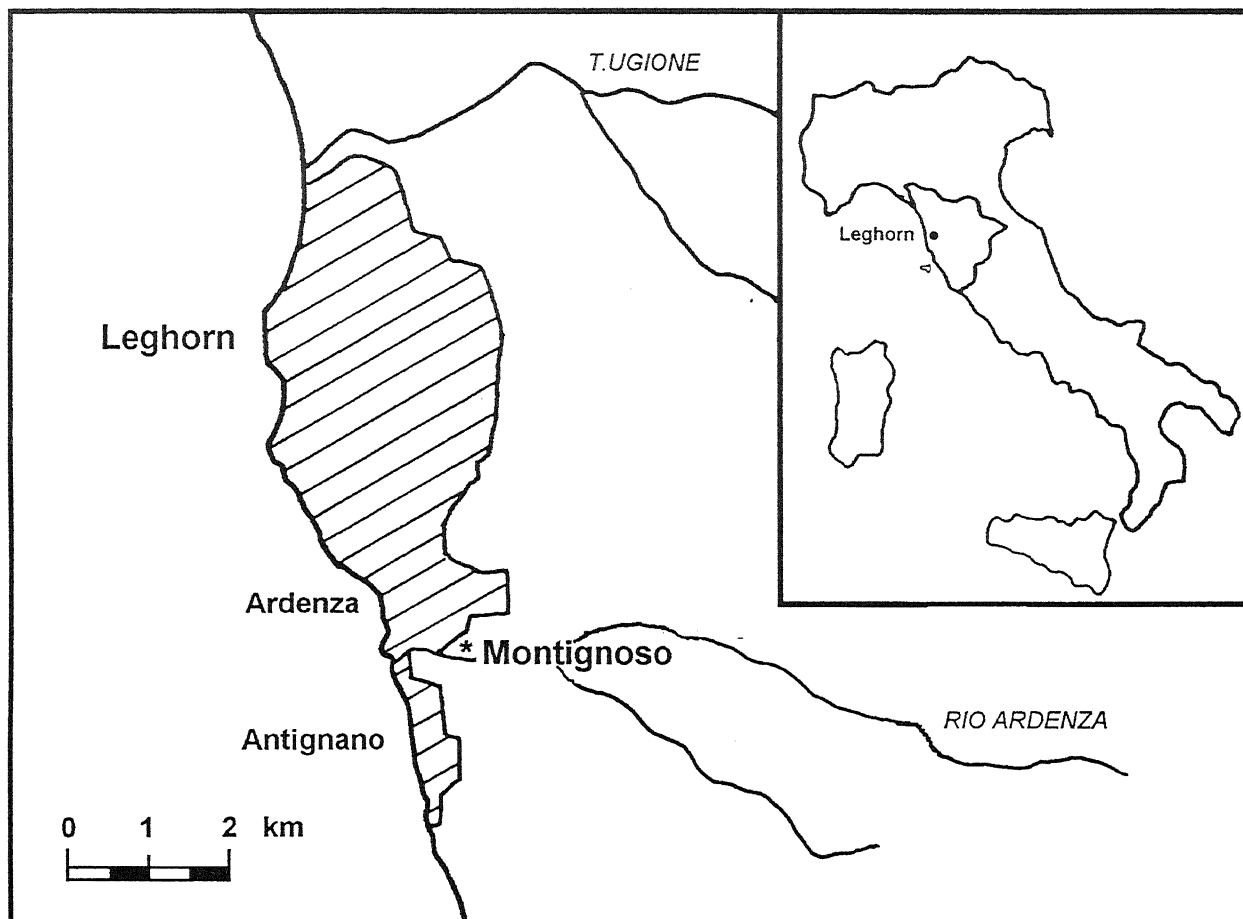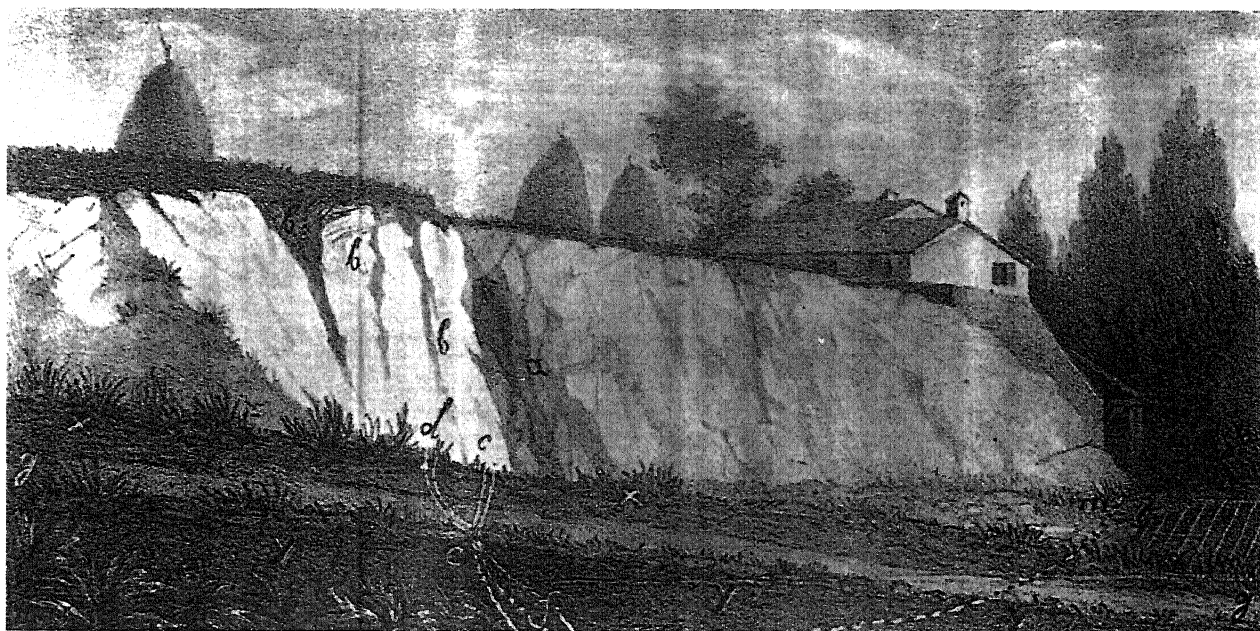
Fig. 1 - Index map.
Carta di ubicazione.

Fig. 2 - View of the site (from Cocchi, 1865).
Vista del sito (da Cocchi, 1865).

Following Badgley (1986), every identifiable bone fragment was called *specimen* here, while the bone fragments manifestly coming from a single individual are *elements*. Badgley (1986) was also followed for the assessment of the number of individuals, distinguishing the NISP (=number of identified specimens per taxon), which, in accordance with the taphonomic history of the accumulation, may be thought to equate the number of individuals, from the MNI, (=minimum number of individuals) which, on the other hand, is assessed by evaluating first the maximum number of left or right long bones and then correcting the results by matching lefts and rights in respect of age and size (Chaplin, 1971). The NISP corresponds to Rustioni *et al.*'s (1994) GTNSF (=Grand Total Number of Skeletal Fragments), which considers a jaw with teeth a single specimen. Also Rustioni *et al.*'s (1994) TNSF (=Total Number of Skeletal Fragments) was calculated here, an index which counts teeth as single specimens even if mounted on jaws.

The body size is the mean of the sum of the biomass value per species, estimated making reference to living representatives of each species. The six juvenile individuals of the site were excluded for the impossibility to evaluate their exact weight. For the extinct species, such as *Elephas (Palaeoloxodon) antiquus* and *Stephanorhinus hemitoechus*, reference was made to extant ecological equivalents of the families.

Simpson's (1949) index ($SI=\Sigma$ $(n^2-n)/(N^2-N)$, where $SI=Simpson's$ *index*, $n=number$ *of individuals in a species*, $N=\Sigma n$) was used to assess the species diversity. It was calculated excluding the faunal components lighter than 5 Kgs.

The age spectrum is given by an average of the percentages of young individuals present for each species.

Behrensmeyer's (1975) tooth/vertebra ratio and the percentages of each bone were used to assess the skeletal-part composition.

Breakage, abrasion/polishing and surface marks were observed and expressed in average percentages. At last, the range of the most represented weathering Stages (*sensu* Behrensmeyer, 1978) was detected.

3. FAUNA

The vertebrate remains are fragmentary and usually poorly preserved. No articulated elements were found.

The following species have been recognized: *Elephas (Palaeoloxodon) antiquus, Equus ferus, Stephanorhinus hemitoechus, Sus scrofa, Hippopotamus* sp., *Cervus elaphus, Dama dama, Capreolus capreolus, Bos primigenius, Bison* sp., *Canis lupus, Vulpes vulpes, Lynx* sp., *Felis silvestris, Panthera pardus, Crocuta crocuta, Ursus arctos, Marmota marmota, Hystrix* sp., *Arvicola cantiana-terrestris, Aquila* sp. and *Aves* indet. Del Campana (1909) reported the occurrence of hare remains, but we could not find these fossils in the collections presently preserved in the Museum of Florence.

3.1 Brief description of the Mammalian species

Elephas (Palaeoloxodon) antiquus

The Straight-Tusked Elephant is represented by 10 fragmentary cheek teeth, three upper and seven lower, and two fragments of tusks. Three deciduous teeth are present. At least three individuals are represented, two adults and a young. The tusk stumps are typically straight and the cheek teeth narrow and elongate. The lamellae are widely spaced.

The Straight-Tusked Elephant dispersed in Europe from the beginning of the Middle Pleistocene to the beginning of the Last Glacial.

Equus ferus

The equid material from Montignoso is referred here to *Equus ferus* and not to the domestic representative *Equus caballus* following Gentry & Clutton-Brock (1996).

Ten specimens can be referred to the wild horse, four of which are upper cheek teeth, five lower cheek teeth, and one is a left astragalus, all referable to two individuals, an adult and a young. All specimens are morphologically and dimensionally very close to the Middle Pleistocene-first Upper Pleistocene representatives of the species.

Stephanorhinus hemitoechus

The Steppe rhinoceros is represented by thirteen specimens, which consist in fragments of two maxillaries, two mandibles, a zygomatic, two isolated cheek teeth, a metapodial, a left ulna, four right carpal bones. The cheek teeth are fairly hypsodont and bear traces of cement. The postcranial bones are sturdy and indicate an animal with graviportally structured limbs. The bones document the occurrence of at least two individuals, an adult and a young.

Sus scrofa

The Wild Hog is slightly represented. The sample includes a left maxillary which still preserves the P^3-M^2 cheek toothrow, a left hemimandible and a first left lower incisor. Only one individual seems to occur.

Hippopotamus sp.

The Hippopotamus material consists in eight fragments: three canines, two upper and one lower, an upper fourth premolar, a maxillary, a left and a right os coxae and the diaphysis of a left femur. The bad state of preservation prevents a sure specifical attribution; however, the proportions of the upper canines, which have fairly developed antero-posterior diameters, suggest a possible reference to *H. amphibius*. All the elements seem to belong to a single adult individual.

Cervus elaphus

The Red Deer is fairly well represented: 38 fragments form the sample, which include four antlers, a left one, two right ones and one indeterminate; six maxillaries, three left ones and three right ones; six mandibles, three left ones and three right ones; nine isolated cheek teeth; twelve postcranial bones. At least three individuals are present, two adults and a young or a young adult.

Dama dama

Eleven elements are referred to the Fallow Deer. The sample includes several cheek teeth, some still mounted on maxillaries and mandibles, and three fragmental limb bones, a left humerus, a left femur and a

left tibia. Only one adult individual seems to be represented.

Capreolus capreolus

Although less well represented than the Fallow Deer, the Roe Deer is present with at least two adult individuals, as the seven bone fragments of this sample seem to suggest. The bone fragments are mostly cranial elements, which include a partial right (?) antler; only a left astragalus forms the postcranial record.

Bos primigenius, Bison sp. and Bos vel Bison

21 bone fragments are confidently referable to the Aurochs. Most are isolated teeth, maxillary and mandible fragments; 8 are fragments of postcranial bones, represented by a cervical vertebra, a right humerus, a right metacarpal bone, a left astragalus, two naviculocuboids, a left one and a right one, two cuneiforms and a right metatarsal bone. At least two adults and one young individual are represented.

Only three specimens show characters typical of the Wisent, a left (?) os cornu, a fragmental left humerus and a right astragalus, all referable to a single individual.

Other nine vertebrae and a third left cuneiform are undecidedly referred here to Bos vel Bison. They denounce the presence of two further individuals, which may thus raise the minimum number of the Aurochs and/or of the Wisent by one or two units.

Canis lupus

Few specimens document the occurrence of the Wolf, two natural endocranial casts, a facial skeleton, an almost complete mandible, two right hemimandibles, a first phalanx. At least three adults are represented. One of the right hemimandibles is particularly small-sized. In our opinion, an attribution of this specimen to Canis lupus mosbachensis or simply to Canis mosbachensis is ruled out by the strong resemblance with typical wolf hemimandibles. It is thus presumed that this small-sized mandible belongs to a female individual of Canis lupus.

Vulpes vulpes

The occurrence of one adult Red Fox is testified by a fragmental cranial, a neurocranium and a left mandible.

Lynx sp.

A fragmental left mandible, still bearing the third lower premolar and the carnassial tooth, documents the occurrence of the Northern Lynx.

Felis silvestris

A right humerus and the fragment of a right (?) tibia are referable, in size, morphology and proportions, to an adult European Wild Cat.

Panthera pardus

The Leopard is represented only by a first phalanx.

Crocuta crocuta

An adult Spotted Hyaena is represented by a fragmental, sturdy right hemimandible, a fragmental left maxillary, still bearing the fourth upper premolar and an isolated second lower premolar.

Ursus arctos

The Brown Bear is the best represented carnivore from Montignoso. At least two adults are documented by a badly preserved skull, a facial skeleton and several fragmental postcranial bones, including a left humerus, a left radius, a left femur and five metapodials. The skull is fairly slender and may belong to a female.

Marmota marmota

The occurrence of an adult Marmot is testified by a fragmental left hemimandible still bearing the incisor and three molars.

Hystrix sp.

A fragmental right hemimandible with the P_4-M_3 tooth row still preserved witnesses the occurrence of a small-sized adult Porcupine. The fourth premolar and the first two molars are very worn, while the third molar is slightly worn (Fig. 3a).

Arvicola cantiana-terrestris

At least eleven adult Voles are documented by a rich amount of cranial and dental material, which amount to 44 specimens. All the molars are rootless. Cement fills partly the re-entrant folds. The enamel of the convex side of the triangles is more or less as thick as that of the concave side, but there are points where the thickness decreases considerably. Two first lower molars, a complete right one (Fig. 3b) and an incomplete left one, are present in the sample. The complete specimen is 4.02 mm long.

The mammalian remains from Montignoso include other seven specimens whose poor state of preservation prevents a sure specific determination.
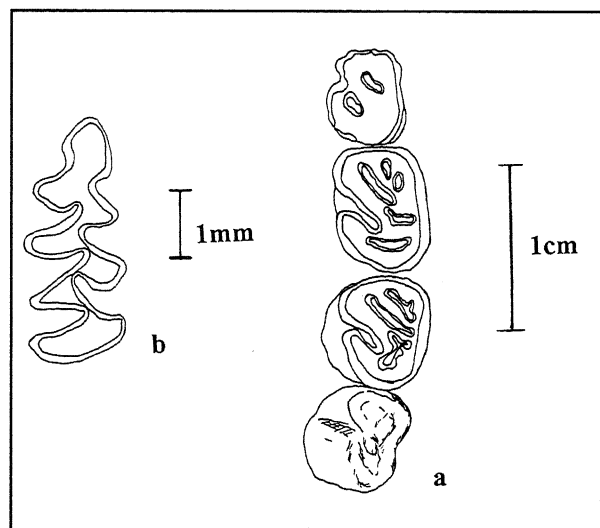

Fig. 3a - Arvicola cantiana-terrestris - right first lower molar, occlusal view.

Arvicola cantiana-terrestris - primo molare inferiore destro, vista occlusale.

Fig. 3b - Hystrix sp. - right P_4-M_3 toothrow, occlusal view.

Hystrix sp. - serie dentaria destra P_4-M_3, vista occlusale.

4. RESULTS

The results of the analyses of the mammal remains from Montignoso are summarized in figs. 4-10.

Fig. 4 shows the fossil-assemblage composition expressed in MNI and NISP. The distribution of bones among the most represented taxa, *Cervus elaphus* and *Bos primigenius*, is shown, respectively, in Figs. 5, 6. Other two istograms show the total amount of each bone type (Fig. 7) and the expected vs. actually found abundances in the most represented taxa, *Cervus elaphus* and *Bos primigenius* (Figs. 8, 9). The graphic representation of the taphonomic analysis is shown in Fig. 10. The TNSF reaches a total of 376.

There is an unusually large amount of carnivores; wolf and bear are the most represented, while the other carnivores are present in comparable abundances. The ungulates are mostly characterized by aurochs, roe and red deer, followed by horse and rhinoceros. Incidentally, the perissodactyls are mostly represented by young individuals. The fallow deer is the least abundant among ungulates. Hippopotamus and wild boar are represented only by one individual

Fig. 6 - Distribution of bones of *Bos primigenius*.
Distribuzione delle ossa di Bos primigenius.
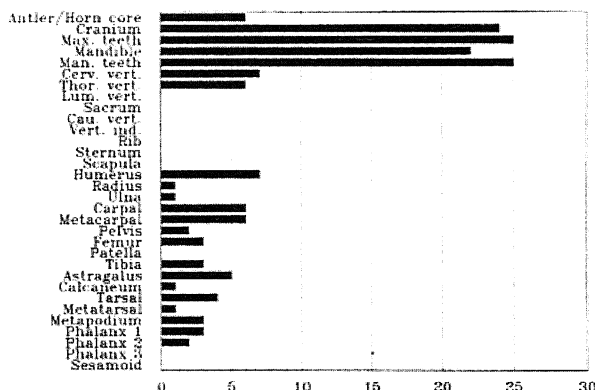
Fig. 7 - Total percentages of each bone type
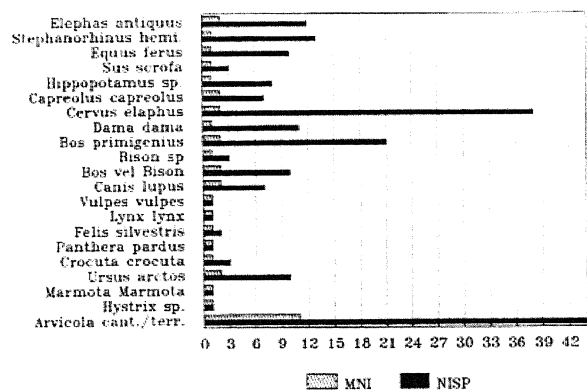*Percentuali totali di ciascun tipo di osso.*

Fig. 4 - Fossil assemblage composition.
Composizione dell'associazione fossile.

Fig. 5 - Distribution of bones of *Cervus elaphus*.
Distribuzione delle ossa di Cervus elaphus.

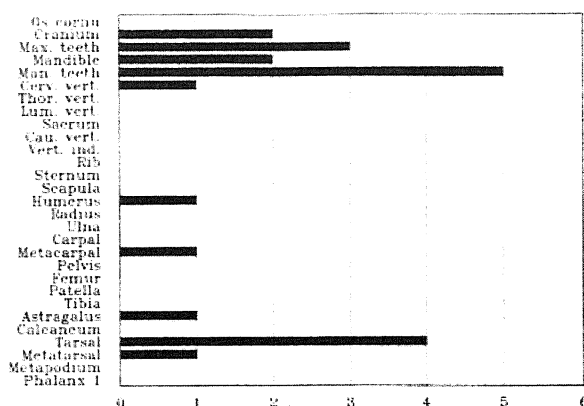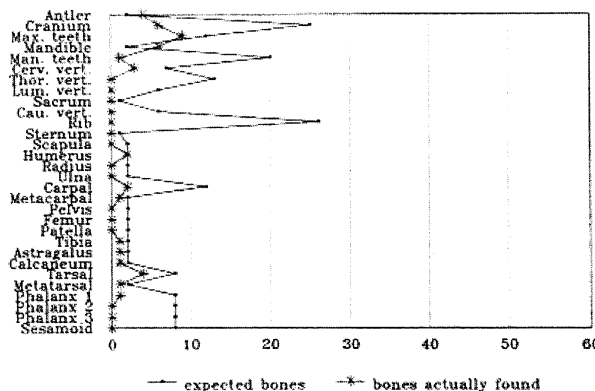Fig. 8 - Expected vs. actually found abundances in *Cervus elaphus*.
Abbondanze attese confrontate con quelle effettivamente rinvenute in Cervus elaphus.
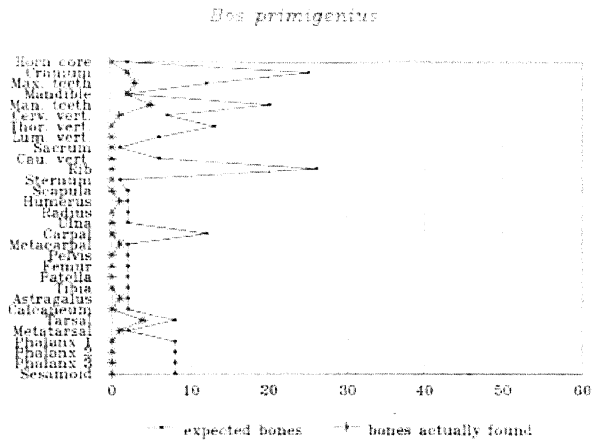
Fig. 9 - Expected vs. actually found abundances in *Bos primigenius*.

Abbondanze attese confrontate con quelle effettivamente rinvenute in Bos primigenius.

each. Proboscidians practically equal in abundance the aurochs, red and roe deer.

Rodents are by far dominated by *Arvicola*, while *Hystrix* and *Marmota* are represented only by one individual each. The length of the M_1 of *Arvicola* is lower than the mean length of M_1 of present day watervoles from England, which is about 4.35 mm (Kolfschoten, 1985), but larger than the mean length of *Arvicola cantiana* molars from Westbury-sub-Mendip (Bishop, 1982), than the mean length of the *Arvicola terrestris* molars from Rhenen, which is 3.53 mm (Kolfschoten, 1981) and than the mean lengths of the *Arvicola* molars from Maastricht-Belvédère, which are 3.08 mm and 3.78 mm, respectively in the molars attributed to the transitional *Arvicola cantiana-terrestris* and in those attributed to *Arvicola terrestris* (Kolfschoten, 1985).

The Simpson's index value is very low, either calculated on MNI or on NISP. This indicates a low species diversity, but the result deserves a more careful analysis. The low value of the Simpson's index seems apparently conflicting with the relatively high proportion of species identified in the sample. However, as Rosenzweig (1995) opportunely observed, Simpson's index of diversity is not indipendent of equitability; as a matter of fact, it rises as the number of species increases, but also as the variation in species abundance decreases. In other words, the value of the index approaches 0 when only few species are represented or in the case of dominance of one or few species and 1 when many species occur or even when species show comparable abundances. In the case of Montignoso, the low values of the Simpson's index is given by the dominance of deer and aurochs in the portion of the community exceeding 5 Kgs (Fig. 4).

Behrensmeyer's (1975) tooth/vertebra ratio reaches a considerably high value, 3.7. This result, combined with the slight presence of young individuals and the isolation, dispersion, sorting and intense fragmentation of the specimens, are suggestive of transportation and winnowing, although the specimens appear unabraded. In many cases, the outer layer of the macromammal bones is removed and the weathered compact bo-

ne is extensively exposed. The specimens are often rough and fibrous; deep cracks and splinters occur. Locally the bone surfaces appear corroded, possibly by humic acids or by bacterial activity. No scrape marks due to human activity or tooth marks of carnivores or rodents were observed.

5. INFERENCES

The curve of the Montignoso fossil community of Fig. 10 shows a fairly good correspondence with the example of an attritionally formed assemblage illustrated by Behrensmeyer (1991). The two curves differ only in the relative abundance of species, which is lower in the Montignoso fauna, because of the already mentioned dominance of deer and aurochs, and in the body size, which, on the contrary, is considerably higher in the Montignoso community. The taphonomic analysis therefore suggests that the Montignoso joint was infilled by sediments probably reworked from a nearby land surface where there was a time-averaged attritional accumulation of mammal remains. Such a conclusion may explain the odd composition of the Montignoso fauna, which is characterized by an unusually well diversified carnivore assemblage and by a co-occurrence of animals with contrasting ecological preferences, such as typical open-space (*Equus ferus, Bison* sp. and *Marmota marmota*) and woodland dwellers (*Sus scrofa, Capreolus capreolus, Lynx* sp., *Felis silvestris, Ursus arctos, Hystrix* sp.) and "warm" (*Elephas (Palaeoloxodon) antiquus, Stephanorhinus hemitoechus, Sus scrofa, Hippopotamus* sp., *Dama dama, Capreolus capreolus, Hystrix* sp.) and "cold" indicators (*Marmota marmota*).

Because of the lack of evidence of carnivore and human activity on the bones the relative abundance of deer and aurochs remains may be explained invoking a natural attritional time-averaged accumulation of carcasses derived from animals which are usually present in larger numbers due to their social or gregarious habits.

Particularly important, from the stratigraphical point of view, are the evolutionary stage of the watervole, the porcupine and the presence of pachyderms. *Arvicola* is represented by a form transitional between
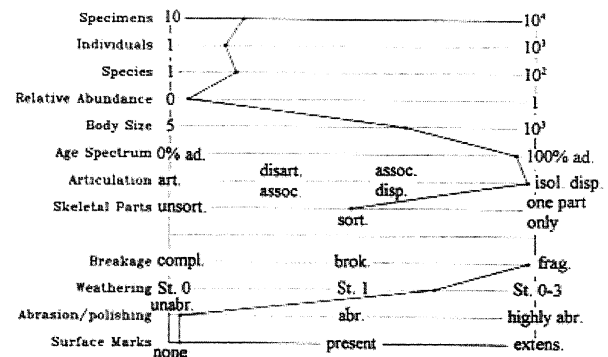

Fig. 10 - Graphic representation of the results of the taphonomic analysis of the mammalian fauna from Montignoso.

Rappresentazione grafica dei risultati dell'analisi tafonomica della fauna a mammiferi di Montignoso.

A. cantiana and *A. terrestris*, which is suggestive of the first stadial of the Saalian (Koenigswald, 1973). *Hystrix* is much smaller-sized than *H. cristata* and than the Early-Middle Pleistocene *H. refossa*. It may likely be referred to Argyropoulo's (1933) *H. vinogradovi*, which is typical of the Eemian (Chaline, 1972). Finally, the persistence of the pachyderms is consistently suggestive of a moment preceding the beginning of the last glaciation.

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