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ITALIAN MAMMAL BIOCHRONOLOGY FROM THE LATEST MIOCENE TO THE MIDDLE PLEISTOCENE: A MULTIVARIATE APPROACH

The biochronological setting till now proposed for the Italian large mammal faunas is based on the definition of faunal units (FUs). These give a very good resolution in the case of Italian faunas, but are less useful in the comparison with other European faunas. The multivariate approach should provide a useful tool in order to define biochronological units in the preliminary recognition of successions of non overlapping, ecologically adjusted, assemblages of taxa, living together in given space and time. A multivariate analysis has been here applied to test the affinity among selected Italian local faunas (LFAs), from the latest Miocene to the late Middle Pleistocene, in order to verify their arrangement within each biochronological unit. The multivariate analysis have been made using two different methodological approaches. The first one is the similarity approach, based on the common presence of taxa; the second is a parsimony based method, that uses the various relationships between FAEs and LAEs. Despite the different conceptual basis of the two methods, the obtained results basically agree. Three main faunal groups can be detected, corresponding to Turolian + Ruscinian (Late Miocene and Early Pliocene, according to the results of parsimony based analysis) or Turolian + Ruscinian + early Villafranchian (according to similarity analysis), (early?) Villafranchian + early Galerian (Middle Pliocene and Early Pleistocene) and middle-late Galerian + early-middle Aurelian (Middle Pleistocene) LFAs. The application of multivariate methodology shows a good resolution in the definition of clusters of highest hierarchical rank. These gather the main part of LFAs belonging to a given "Mammal Age" and constitute a well-characterised complex, while some problems are related to the interpretation and biochronological definition of lower hierarchical rank groups.

KEY WORDS: *Biochronology, Large Mammal Faunas, Neogene-Quaternary, Italy*

PAROLE CHIAVE: *Biocronologia, Grandi Mammiferi, Neogene-Quaternario, Italia*

Introduction

Various authors (e.g. De Giuli *et al.*, 1984; Lister, 1992; Lucas, 1992; Lyndsay, 1985, 1997; Lyndsay & Tedford, 1990; Pickford, 1990; Prothero, 1995; Tedford, 1970; Alberdi *et al.*, 1997; Azanza *et al.*, 1997; Walsh, 1998, and references within) noted that several factors make difficult to apply chronological time scale to continental faunas especially in the case of large mammal faunas. In the continental environments, long stratigraphical sequences are very rare. The fossil mammals mainly occur in localised fossiliferous fluvial-lacustrine alluvial deposits, fissures or isolated pockets frequently outcropping in caves, quarries or natural sections limited in thickness and extension. Besides, land mammals are generally less likely to be preserved in the sediment. The richness as well as the presence or absence of some taxa in a given mammalian assemblage depend on random factors. So, continental successions are largely discontinuous and cases of superposition cannot be recognised in stratigraphic succession. Without the support of stratigraphic control, the chronological faunistic sequence is based on the stage of evolution reached by selected,

well definite lineages of mammals and on the basis of bioevents which ought to have wide territorial significance. Several kinds of problems (discontinuity of continental environments, «provincialism» of continental faunas, influence of geomorphologic and/or climatic factors, wideness and speed of mammal dispersal, metachronic and diachronic, difficulty to distinguish whether an immigration or an extinction event has occurred etc.) make difficult to recognise whether two local faunal assemblages are contemporary or superposed in time. Thus, it is difficult to define continental biochrons that should be utilised on an extensive scale, especially in the case of large mammalian faunas.

Also the higher-level biochron units, the so-called «Mammal Ages» (MAs), are prevalently based on FODs (First Occurrence Datums) and LODs (Last Occurrence Datums), so the biochrons tend to have mainly local significance. Taken into account the problems to define biochronologic units on the basis of appearance/disappearance events of a single taxon, several authors prefer to use associations of characteristic taxa, living together in space and time. The faunal unit (FU), based on all species from local faunas

selected as typical associations, represents the biochron of the lowest rank. The FUs can be grouped in higher level faunal complexes as the Mammal Ages.

To define the chronological framework of Italian mammal faunas, several schemes have been proposed by several authors (for instance Ambrosetti *et al.*, 1972; Azzaroli, 1977a, 1982, 1983, 1991; Azzaroli *et al.*, 1988a, b; De Giuli *et al.*, 1984; Torre *et al.*, 1992, 1996; Caloi & Palombo, 1990, 1996, 1997; Gliozzi *et al.*, 1997; Petronio & Sardella, 1999). Initially a subdivision in six FUs has been proposed by Azzaroli (1977a) for the mammal faunas belonging to Villafranchian MAs. Successively, the discovery of new faunas, the increase in the knowledge of faunal renewal phases, the transitional character of some assemblages, allow to introduce some new FUs and/or to propose new MAs. Recently, a new biochronological scheme has been proposed for the Italian continental faunas, large and small mammals, fresh-water molluscs and brackish ostracods, from the Middle Pliocene to the Late Pleistocene (Gliozzi *et al.*, 1997). Three MAs have been defined: Villafranchian, Galerian and Aurelian, which gather eight (Triversa, Montopoli, Saint Vallier, Costa San Giacomo, Olivola, Tasso, Farneta, Pirro), four (Colle Curti, Slivia, Isernia, Fontana Ranuccio) and more than two FUs (Torre in Pietra, Vitinia, non defined) respectively (Fig. 1). Moreover, the transitional character of some local faunas was pointed out (see discussion in Gliozzi *et al.*, 1997). Later, Petronio & Sardella (1999) proposed that the Ponte Galeria local fauna has to be considered as a distinct middle Galerian FU, transitional to Isernia FU.

The biochronological setting till now proposed for the Italian large mammal assemblages gives a very good resolution in the case of Italian faunas, but are less useful in the comparison with other European faunas. As previously pointed out, several factors limit the comparison among faunal complexes belonging to different geographic areas. Moreover, in the case of Italian faunas, during the Plio-Pleistocene, sharp and important faunal changes are rarely recognisable and the transition between successive faunal assemblages often involves a restricted number of species or sub-species.

This can make it difficult to define the taxonomical composition of the faunal complex to be chosen as typical of each FU.

Different kind of multivariate analysis, applied to test the affinity and temporal sequence/ordination among selected Italian local faunas (LFAs) from the latest Miocene to the late Middle Pleistocene, can constitute a useful help in order to resolve this problem. Our aim is to quantify the similarities among the local mammal assemblages, which allow us to establish successive local faunal changes, and to compare these patterns with the previously established local biochronological schemes. In recent years, several multivariate approaches have been developed trying to

supplement the similarity and association concepts. These methods use the various relationships between FADs and LADs of taxa as the basic data, which can be compiled by searching real association of taxa in LFAs, or by virtual association from the superposition of stratigraphic ranges. Nevertheless, eventual ambiguities or incongruences should be resolved using parsimony criteria. The parsimony-based methods are more appropriate to establish a temporal sequence/ordination of LFAs.

Material and Methods

Among large mammal faunas from the Latest Miocene to the late Middle Pleistocene, 69 LFAs were selected, as summarised in the Appendix, in which some taxonomical and biochronological observations are also pointed out. Although, the local faunas have been chosen based on their richness, all classic continental fauna belonging to the Turolian MA and the poor Ruscinian Val di Pugna fauna have been selected. Among the Villafranchian and Galerian local faunas, some assemblages including few taxa have nevertheless also been considered to test their similarity with the typical fauna belonging to the same FU.

The main mammal assemblages selected among the late Middle Pleistocene local faunas are from Latium area. This fact depends on the richness of deposits that are mainly located in the Tyrrhenian Latium coast or in the «Campagna Romana». These faunas can provide a good validity test for the similarity analysis. In fact, we can note that assemblages apparently belonging to the same stratigraphical horizons and showing similar stratigraphical relationships, do not necessarily have similar taxonomical composition. Moreover, each local fauna shows some differences in the frequency of species that lived in open or forest environments. In the case that a clear stratigraphical relationship cannot be detected, we can hypothesise that the variability might be explained in terms of human activity, or random variations, or short-term changes in local climate, or even microclimate. Consequently, it should be interesting to compare the faunal and paleoenvironmental data with the results of the multivariate analysis.

Sites including more than one faunal level are separated as different LFAs. The localities, which include several fossiliferous sites, or levels, whose relative stratigraphic positions are not well established, were excluded. In the analysis 150 species of large mammals were considered. The faunal list of each locality was critically reviewed, including up-to-date records and personal observations. Only terrestrial large mammals have been considered due to the analysed LFAs not including significant small mammal faunas; moreover, the micromammal faunas are often rich in species but the large mammal

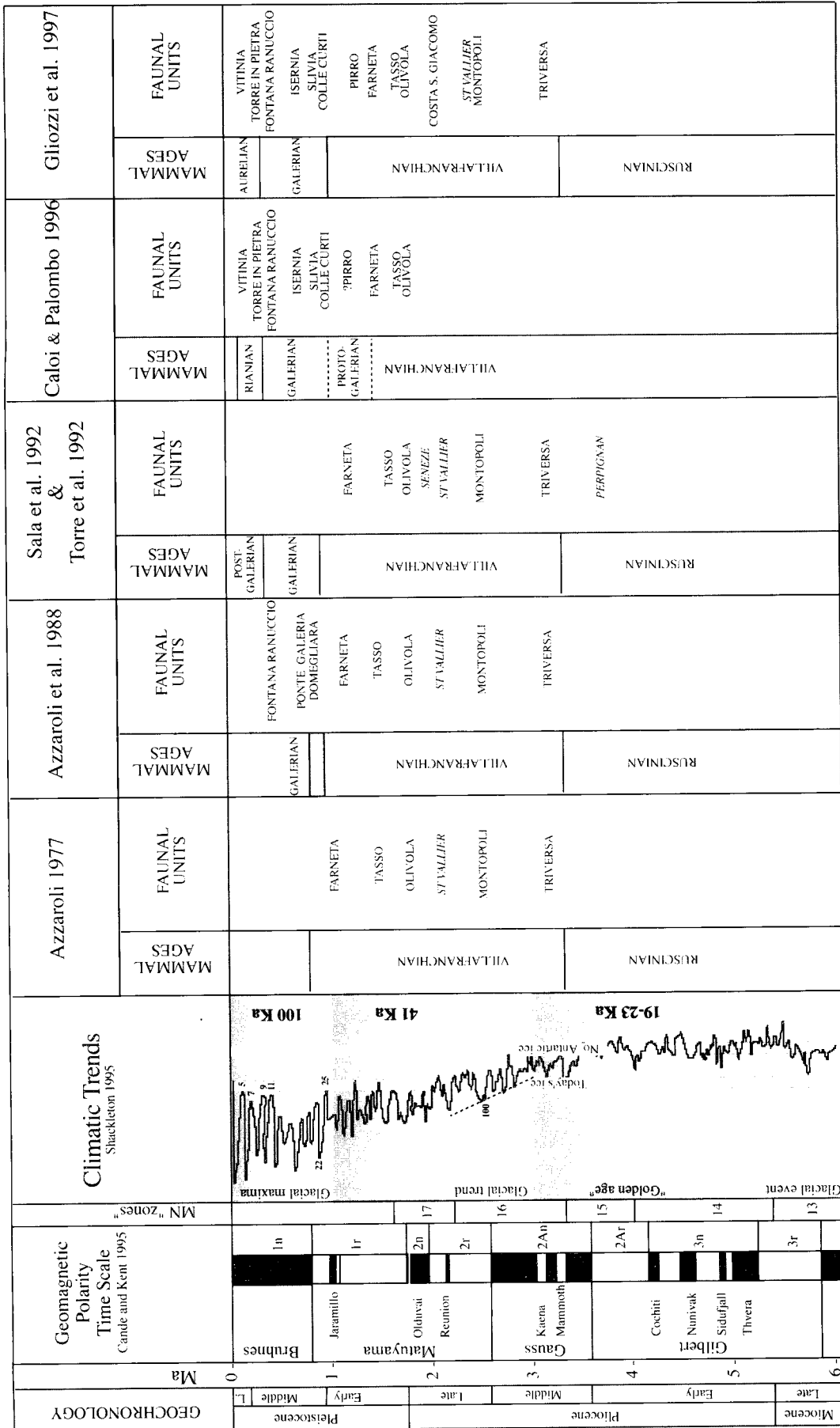


Fig. 1 – Scheme showing selected propositions for Italian Mammal biochronology. The position of the boundary between two successive Mammal Ages is only indicative because of the possibility to define only the time over which the faunal renewal have been occurred
 – Schema di confronto fra alcune proposte per la biochronologia delle mammalofaune italiane. Il limite posto tra le singole Età a Mammiferi è solo indicativo data l'impossibilità di definire con precisione il momento del passaggio tra due successive Età.

records are lacking or sparsely represented. Firstly, the analysis have been made on the specific taxonomic level. For a quantitative approach, the use of genera introduces a greater bias than species, since some groups, such as carnivores, include many monospecific genera, while others, such as equid genera, grouped many species. On the other hand, in the case of not very rich assemblages, the use of subspecies greatly reduces the similarity. Nevertheless, because of the biochronological subdivision of Italian mammal faunas in FUs is in some cases based on the new occurrence of subspecies, we have included these taxa in the analysis.

We have standardised the taxonomy, including forms identified as *confer* (cf.) within the nominal taxon. The "affinis" (aff.) have been usually considered as different taxa. The taxa certainly different at specific level but not yet defined as n.sp. or for which taxonomical attribution there is not agreement among the authors, have been indicated as «sp.». The taxa of doubtful taxonomic definition and/or representative of successive evolutionary stage not clearly defined, or considered at different taxonomic rank by the various authors, have been grouped into «group».

The NTSYS-PC program, version 2.0 (Rohlf, 1998) was used in the similarity analysis. The initial matrix has been edited and effectively processed by the multivariate method and computing programs have been used. No further data transformations have been made in the data-editing step. The presence of a taxon in a sample is the basic data unit, and therefore binary coefficients can be used in most biostratigraphical work (Hazel, 1970). Absence of a taxon in a locality may derive from ecological and/or biogeographical bias, differential preservations, and/or poor sampling, rather than from temporal factors. So, common absence conveys no precise information and cannot be interpreted as an indication of similarity. Several conventional binary similarity coefficients available in the literature do not consider mutual absences. Among them, the Jaccard coefficient satisfies also the following conditions (Shi, 1993), that are preferable in our analysis: - It has only positive values ranging from 0 (totally different) to 1 (identical) - It is metric and symmetrical - It is little affected by differences in sample sizes - It has a near-linear relationship with the increase of the number of shared taxa.

The clustering technique was the unweighted pair-group method using arithmetic averages (UPGMA). In the UPGMA, the level at which a member will join an existing cluster is based on average similarities of all the existing members calculated from the original matrix of coefficients. Thus, each member of a cluster has equal weight at all levels of clustering. The cophenetic correlation coefficient (CCC) was computed as a measurement of distortion (Farris, 1969). Among the agglomerate hierarchical clustering techniques, UPGMA yield a greater CCC indicating less amount

of distortion in the dendrogram relative to the original similarity matrix (Hazel, 1970; Shi, 1993).

Q-mode analysis relates LFAs to each other on the basis of the present species. In individual sections where fossils are abundant, the dendrogram reproduces the stratigraphic position of the samples in the section and indicates their relative faunal similarities (Hazel, 1970).

We also used the program CONJUNCT Version 1.5 of Alroy (1992, 1994) following the analysis «appearance event ordination» (AEO; Alroy, 1994). The chronological information is inferred detecting which taxa appear before the last occurrence of another. These F/L statements could be inferred from common occurrences in LFAs or from superposition in stratigraphic sections and have been used to constrain a relative sequence of FAEs and LAEs. The «best» solution to this procedure, involving correspondence analysis, is to search for a parsimonious arrangement of events that minimise the overall number of implied F/L relationships. We use surviving taxa to «polarise» the ordination and eliminate false LAEs. The 69 selected LFAs are ordered there in the event sequence by computing a «concurrent range zone», which is just the narrowest range of events across the sequence that spans the range zones of all taxa found in a locality (Alroy, 1998). The order is determined by the midpoint of these range zones, i.e. the mean of the number of the rightmost left event and the number of the leftmost right event. The event sequence was calibrated by regressing the midpoints of the LFA ranges against radioisotopic and paleomagnetic ages available for some LFAs (see Appendix).

Results

The Q-mode dendrogram, resulting from the clustering of similarities among Italian LFAs based on the occurrences of species, shows a separation in two main groups that reflect one main gap (Fig. 2). The first main cluster (cluster A) gathers the most archaic LFAs in which Neogene taxa prevail: two groups of lower hierarchical rank can be detected, that group together the latest Turolian (Gravitelli LFA and cluster A.1) and the Ruscinian plus early Villafranchian (Val di Pugna LFA and cluster A.2) localities respectively. The only exception is represented by the Colle Pardo LFA locality, that was generally attributed to middle Villafranchian MA (Gliozzi *et al.*, 1997). Actually, among the few taxa represented in this fauna, only *Megantereon cultridens* does not surely occur in the Italian early Villafranchian LFAs.

Among the Turolian localities, Baccinello V3 and Casino display the highest similarity, while Gravitelli is the most detached, as expected. In the second Ruscinian plus early Villafranchian group, the poor Valle di Pugna LFA, despite the presence of *Alephis liryx*

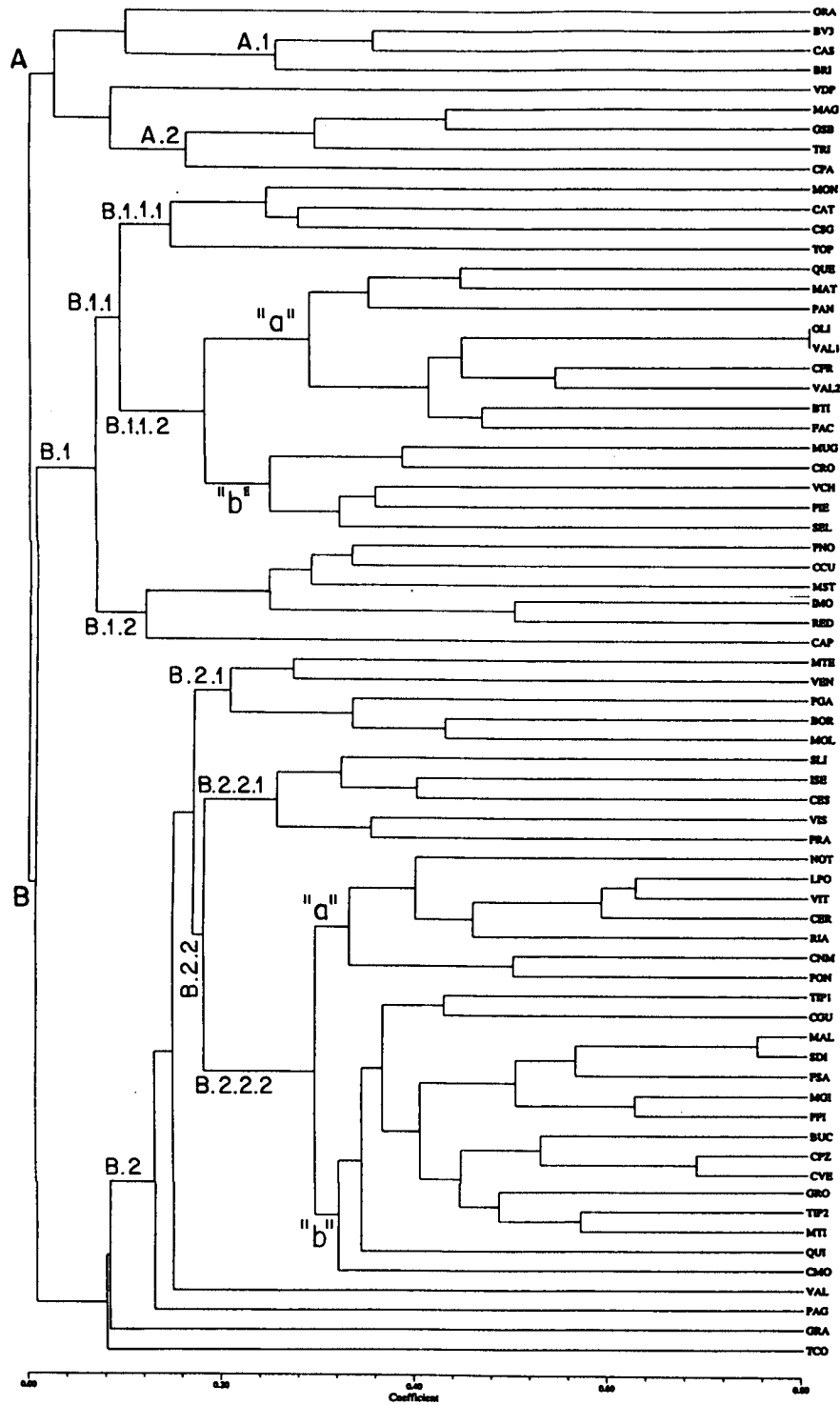


Fig. 2 – Dendrogram for 69 Italian local faunal assemblages (Q-mode) based on un-weighted data of 150 species. CCC = 0.91712. Abbreviations: GRA: Gravitelli; BV3: Baccinello V3; CAS: Casino; BRI: Brisighella; VDP: Val di Pugna; MAG: Ponzano di Magra; GSB: Gaville Santa Barbara; TRI: Triversa; CPA: Colle Pardo; MON: Montopoli; CAT: Valle Catenaccio; CSG: Costa San Giacomo; TOP: Cava Toppetti; QUE: Quercia; MAT: Matassino; PAN: Pantalla; OLI: Olivola; VAL1: Upper Valdarno 1; CFR: Casa Frata; VAL2: Upper Valdarno 2; BTI: Bacino Tiberino; FAC: Fontana Acetosa; MUG: Mugello; CRO: Il Crostolo; VCH: Val di Chiana; PIE: Pietrafita; SEL: Selvella; PNO: Pirro Nord; CCU: Colle Curti; MST: Madonna della Strada; IMO: Imola; RED: Redicicoli; CAP: Capena; MTE: Monte Tenda; VEN: Venosa-Loreto; PGA: Ponte Galeria; BOR: Borgonuovo; MOL: Monte Oliveto; SLI: Slivia; ISE: Isernia La Pineta; CES: Cesi; VIS: Visogliano; FRA: Fontana Ranuccio; NOT: Notarchirico; LPO: La Polledrara di Cecanibbio; VIT: Vitinia; CER: Cerveteri; RIA: Riano; CNM: Cava Nera Molinaro; PON: Pontecorvo; TIP1: Torre in Pietra (lower); CGU: Castel di Guido; MAL: Malagrotta; SDI: Sedia del Diavolo; FSA: Fara Sabina; MGI: Monte delle Gioie; PFI: Prati Fiscali; BUC: Bucine; CPZ: Casal de' Pazzi; CVE: Campo Verde; GRO: Grotta Romanelli; TIP2: Torre in Pietra (upper); MTI: Montignoso; QUI: Capri-Quisisana; CMO: Contrada Monticelli; VAL: Valdemino; PAG: Paglicci; GRA: G.R.A. Roma; TCO: Torrente Conca.

– Dendrogramma ricavato per 69 faune locali italiane (Q-mode) sulla base dell'analisi di 150 specie. CCC = 0.91712. Abbreviazioni: come sopra.

and *Dicerorhinus megarhinus*, is also included. This fact is probably due to the occurrence of *Sus minor*, a typical Villafranchian long-term taxon. Ponzano di Magra LFA is more related to Gaville-Santa Barbara LFA, according to the low number of taxa, that increases the power of common species. Both localities are more closely related to each other than to the Triversa LFA, whose richness should increase in an anomalous way its differentiation.

The second main group (cluster B) gathers all other LFAs belonging to the middle and late Villafranchian, Galerian and early middle Aurelian MAs. Two major clusters (cluster B.1 and cluster B.2) can be detected, that correspond to Middle Pliocene-Early Pleistocene (cluster B.1 – middle + late Villafranchian and early Galerian MAs, from Montopoli to Colle Curti FUs) and Middle Pleistocene LFAs respectively (cluster B.2, middle-late Galerian and early-middle Aurelian MAs, from Slivia to Vitinia FUs). This subdivision reveals one very important gap corresponding to the faunal turnover taking place about on 2.6 Ma. The survival in Montopoli FU of some herbivores and carnivores occurring at the Triversa FU, does not reduce the break between these two faunal complexes. A minor gap detaches the latest Early Pleistocene LFAs (Pirro and Colle Curti FUs, cluster B.1.2) from other middle late Villafranchian FUs (cluster B.1.1). In the cluster B.1.1 two groups of lower hierarchical rank can be detected, that correspond to middle Villafranchian (Montopoli and Costa San Giacomo FUs) (cluster B.1.1.1) and early late Villafranchian (Olivola, Tasso and Farneta FUs) (cluster B.1.1.2) respectively. According to the stratigraphical data, the local faunas from Costa San Giacomo and Valle Catenaccio are more closely related to each other. The Cava Toppetti local fauna have a low degree of similarity depending on the low number of recorded taxa, even if typical of Montopoli FU. In the cluster B.1.1.2, the group "a" gathers the LFAs belonging to Olivola and Tasso FUs, that are characterised by a rather high degree of similarity.

The local faunas from Quercia, Pantalla and Matassino constitute a separate group. This fact can be explained by the quite low number of taxa available for similarity analysis. Thus, the power of the common taxa increases. Surprisingly, the occurrence of *Anancus* in the Quercia LFA does not seem to be of any relevance. The group "b" includes some local faunas belonging to the latest Villafranchian (Farneta FU), that are characterised by the presence of some new taxa as *Megaceroides obscurus*.

In the cluster B.1.2, the latest Villafranchian Pirro Nord LFA (Pirro FU) falls together with the early Galerian LFAs (Colle Curti FU). The Colle Curti local fauna, which falls in the subgroup of late Early Pleistocene assemblages, have been conventionally chosen by Italian vertebrate palaeontologists (Gliozzi *et al.*, 1997) to mark the beginning of «Galerian Mammal Age». This local fauna, characterised by the FOD of

Megaceroides verticornis, was found in sediments with normal polarity, correlated with the base of the Jaramillo magnetic subchronozone (Torre *et al.*, 1996; Albanelli *et al.*, 1997; Coltorti *et al.*, 1998). Colle Curti LFA is not very rich and includes several Villafranchian taxa, thus the large mammal assemblage, in spite of innovative character showed by the arvicolids, seems closer related to be Villafranchian than to the true Galerian LFAs. Actually, Pirro Nord and Colle Curti assemblages show a relatively high coefficient of similarity, depending on the presence in both localities of several common taxa (carnivores, rhinoceros, hippopotamus). This fact markedly reduces the importance of the new occurrence of *M. verticornis* in the Colle Curti fauna.

The group of Middle Pleistocene LFAs (cluster B.2) is very composite. Some LFAs show a low degree of affinity depending on the low number of taxa (Cava Nera Molinario and G.R.A. LFAs) or on the peculiarity in their taxonomical composition (Paglicci and Torrente Conca LFAs). Other LFAs are separated in two groups: cluster B.2.1, grouping some middle Galerian LFAs, and cluster B.2.2, in which two lower ranks groups can be detected, that mainly include the middle Late Pleistocene (cluster B.2.2.2) and the middle Galerian LFAs (B.2.2.1) respectively.

In the cluster B.2.2.1, the localities of Slivia and Isernia+Cesi are closely related. The faunas of these sites belong respectively to the two Italian middle Galerian FUs (Slivia and Isernia), which are representative of the faunal renewal that took place at the end of the Early Pleistocene when important variations in the climatic conditions and in the cyclicity of climatic fluctuations occurred. The renewal, either due to local evolution of pre-existing taxa or by immigrations from Asia and/or Central Europe, took place in two successive phases. The new composition of large mammal assemblages shows a «modern» character. Some Villafranchian large carnivores are still present, but the faunal complex gathers a lot of taxa, which will be present in the following, more recent, assemblages. Thus, the middle Galerian faunas are more closely related to the Italian early and middle Aurelian (late Middle Pleistocene) than early Galerian faunas. The other middle Galerian LFAs fall, rather separate, in a group (cluster B.2.2) which is less related to the Aurelian LFAs (cluster B.2.2.2). This quite anomalous position might be explained by taking in to account the presence of some «Villafranchian» taxa in the Ponte Galeria LFA. The local fauna of Notarchirico (group "a" in cluster B.2.2.2) shows a rather anomalous position. However, the Notarchirico LFA includes few species, the main ones being also common in the late Middle Pleistocene LFAs. *Valdemino* LFA seems to be more related to middle Galerian LFAs, it does not fall in this group.

The late Middle Pleistocene Italian LFAs, gathered in the cluster B.2.2.2, have been separated in two dif-

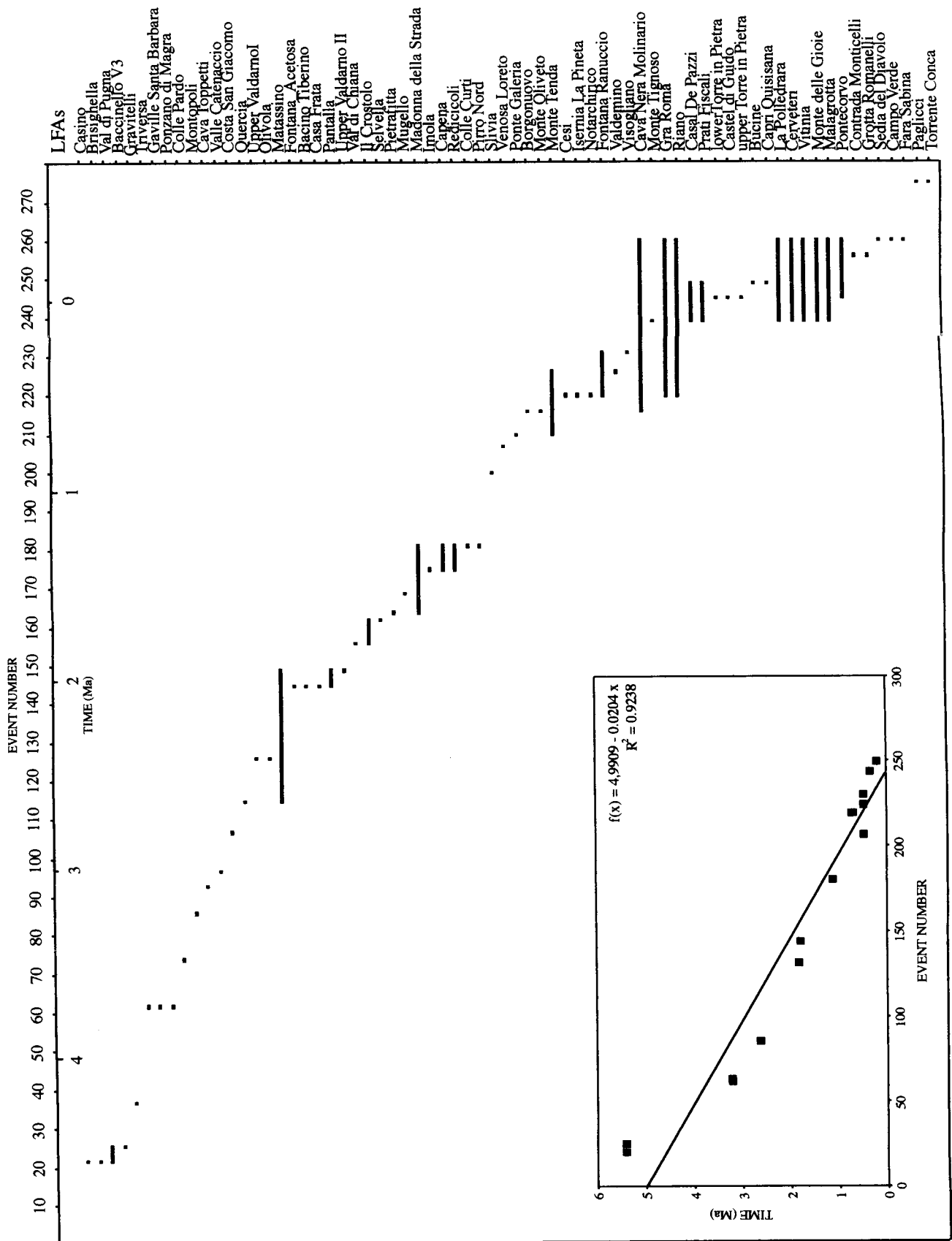


Fig. 3 - The localities ordering after "parsimony-based approach" Disjunction Distribution Ordination (Alroy, 1992, 1994).

- Le località ordinate secondo il "principio di parsimonia" Ordinamento di Distribuzione Disgiunta (Alroy, 1992, 1994).

ferent FUs, Torre in Pietra and Vitinia, on the basis of the occurrence, in the younger of these, of an archaic subspecies of fallow-deer, *Dama dama tiberina*. Moreover, the rich assemblages belonging to these FUs, have been found in deposits outcropping along the Latium coast and belonging to two different, superposed, geological Formations, Torre in Pietra (stages 10-8) and Vitinia (stage 7-6) Formations (Conato *et al.*, 1980; Caloi *et al.*, 1998).

In the Q-mode dendrogram, the localities previously attributed to Torre in Pietra FU (La Polledrara, Castel di Guido, Malagrotta, Torre in Pietra lower level) and Vitinia FU (Vitinia, Sedia del Diavolo, Casal de' Pazzi, Torre in Pietra upper level) are grouped in a quite anomalous way. This fact may be explained by the basic homogeneity of the faunal assemblages as well as by the importance that could take in the analysis the ecological differences or the taphonomical biases in given localities.

On the basis of the results obtained from the appearance event ordination analysis, the taxa recorded in the 69 LFAs and two stratigraphical sections (Upper Valdarno and Torre in Pietra) demonstrate a total of 7952 F/L statements, of which only 94 (0,01%) are stratigraphic F/L statements. The appearance event sequence derived from the AEO analysis implies 15952 F/L statements, thus no more than 0,49% of the inferred F/L statements are known.

The LFAs are ordered there in the event sequence (Fig. 3) by computing a «concurrent range zone». The order is determined by the midpoint of these range zones, i.e. the mean of the number of the rightmost left event and the number of the leftmost right event. The succession of the LFAs is greatly coincident with the previous biochronological setting results.

The event sequence was calibrated by regressing the midpoint of the LFA range against radioisotopic and paleomagnetic ages available for some LFAs (see Appendix). Linear regression was highly significant ($r^2 = 0.92$) especially taking into account the low percentage of LFAs for which a chronological calibration is available.

According to the results, several relevant gaps between the LFAs ordered in the appearance event sequence (Fig. 3) are noted, allowing us to establish tree main groups of LFAs corresponding to pre-Villafranchian (Miocene to Lower Pliocene), Villafranchian+early Galerian (Middle Pliocene to Early Pleistocene) and middle-late Galerian+early-middle Aurelian (Middle Pleistocene) LFAs (Fig. 3). The main gap corresponding to the transition between Ruscinian and Villafranchian should be over emphasized: some bioevents (FAEs and LAEs) could not be taken into account because of the lack of well documented Ruscinian faunas. On the other hand, in this kind of analysis, the persistence of «Ruscinian» taxa in the assemblages belonging to Triversa FU has not relevance. The gap between Early and Middle Pleistocene

LFAs clearly separates the two groups of faunal complexes. There in each group, some minor subdivision should be singled out or hypothesised. For instance, the break between Triversa and Montopoli FU is filled by the Colle Pardo FUs, in which the new occurrence of *Hemitragus stehlini* is actually doubtful. If this bioevent is not considered, the gap would be more important. Taking into account the presence of assemblages formed by taxa of long-term range, more data need to confirm the gap between Olivola and Tasso FUs as well as between Galerian and Aurelian MAs.

Within the first and second groups, the succession of LFAs greatly correspond to the biochronological succession of faunal units, while some discrepancies result from the ordering of LFAs in the third group. For instance, the Pirro Nord local fauna does not precede the Colle Curti fauna, even if in this later *Megaceroides verticornis* firstly occurs, moreover the Venosa-Loreto LFA precede some LFAs usually considered less advanced as the Ponte Galeria LFA, in which, inside, some new form as *Megaloceros savini* and *Bos galerianus* occur. Depending on the slight difference between the faunal complexes belonging to Torre in Pietra and Vitinia FUs, the ordering of LFAs does not correspond to this subdivision.

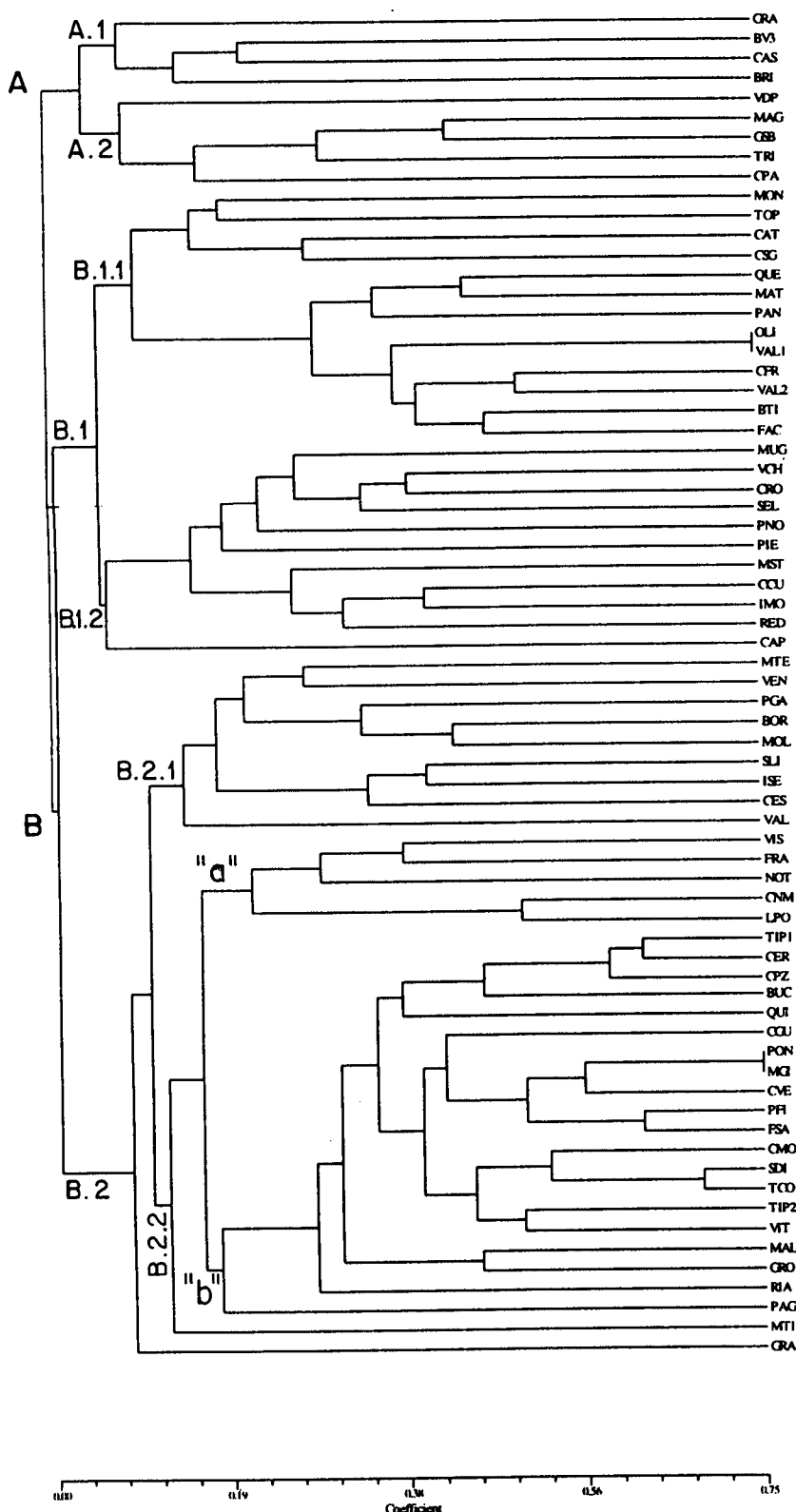
Discussion

Comparing the results of both similarity and parsimony-based multivariate analysis, a relative arrangement of groups of LFAs, according to the time, can be revealed. The dendrogram (Fig.2) shows the existence of two large distinct aggregates of LFAs. Cluster A (Turolian-Ruscinian and early Villafranchian LFAs) and cluster B (late Villafranchian, Galerian *sensu lato* LFAs, *sensu* Bonadonna & Alberdi, 1987b). Both aggregates have scarce common taxa between them, but it is difficult to affirm that each one forms part of «an ecologically adjusted group of animals with specific geographic limits and chronologic range» (Tedford, 1970:602). Alberdi *et al.* (1997) have informally named this kind of aggregates «Superages», considering them equivalent to the Chronofauna concept (*sensu* Tedford, 1970; Emry *et al.*, 1987). The transition between aggregates have reflected a paleocommunity reorganisation mainly depending on concurrent environmental change.

Nevertheless, the lack of typical Ruscinian LFAs in Italy could play an important role to join early Villafranchian to Ruscinian LFAs. Thus, the separation between Turolian+Ruscinian+early Villafranchian and middle Villafranchian LFAs should be emphasised in respect to the faunal turnover from the Ruscinian to Villafranchian. This renewal is characterised by the disappearance of many taxa which are typical of humid and dense forest environment and the appearance of some taxa that inhabit more or less open environments.

Fig. 4 – Dendrogram for 69 Italian local faunas assemblages (Q-mode) based on un-weighted data of 157 taxa, species plus some subspecies considered as important from a biochronological point of view. CCC = 0.91241. Abbreviations as in Fig. 2.

– Dendrogramma ricavato per 69 faune locali italiane (Q-mode) sulla base dell'analisi di 157 taxa, specie più alcune sottospecie ritenute di maggior significato biochronologico. CCC = 0.91241. Abbreviazioni come in Fig. 2.



It can be correlated with the climatic cooling and afterwards with the more important climatic crisis that took place at 3.2/3.1 Ma. However, this faunal break is not highlighted in the dendrogram scheme.

According to the results of similarity analysis, the faunal renewal, which marks the transition between Triversa FU and Montopoli FU seems to be the most important. At this moment, the taxa of wooded habitat

disappears and the occurrence of new taxa increases the percentage of species that are indicative of open landscapes, as *M. meridionalis gromovi* and *Equus livenzovensis*. From the beginning of the middle Villafranchian, several bioevents, more or less separate during the time, progressively have affected the taxonomical composition of the ecologically adjusted group of animals. So, the second of two main clusters seems to be too compound to represent a «Superages» (*sensu* Alberdi *et al.*, 1997). It is interesting to note that the late Villafranchian LFAs belonging to Olivola, Tasso and Farneta FUs, show a higher degree of similarity with respect to middle than to the latest Villafranchian LFAs, that fall in the early Galerian LFAs group.

The faunal complexes of Olivola and Tasso FUs show a marked change because of the disappearance of the majority of the Pliocene species, the dispersal of new large carnivores, as well as the widespread of modern dogs, and the relative abundance of large herbivores, which inhabit open environment. In the LFAs belonging to Farneta, Pirro and Colle Curti FUs (cluster I), most of the typical Villafranchian taxa progressively disappear or become rare. On the contrary, the species phylogenetically related or identical to the Galerian Middle Pleistocene ones progressively appear. According to the results of the analyses, this renewal phase seems to acquire a greater importance than that which took place at the transition from the middle to the late Villafranchian. At the end of the Early Pleistocene, a progressive important faunal change took place and the faunal assemblages acquired typical «Quaternary» characters. Several data seem to confirm the transitional character between typical late Villafranchian and typical Galerian faunas, however the «early Galerian» faunas calibrated with the Jaramillo magnetic subchronozones are more closely related to the late Villafranchian fauna. A second main gap seems to coincide with the important climatic changes that took place at the beginning of the Middle Pleistocene. This is consistent with the data previously resulting from the turnover analysis applied to the FUs Italian complexes (Caloi & Palombo, 1999; Sardella *et al.*, 1998). The renewal, either due to local evolution of pre-existing taxa or by immigrations from Asia and/or Central Europe, took place by two successive phases, as showed by the taxonomical composition of the Slivia and Isernia FUs. This datum does not result from the analysis of similarity, according to which the grouping of LFAs seems to depend more on the richness of each fauna and/or some diversity in composition, due to ecological or taphonomical factors, than to presence/absence of new taxa. The advanced character of early Galerian LFAs as Notarchirico and Fontana Ranuccio is confirmed by the insertion of this fauna there in the Aurelian LFAs group.

According to results of similarity analysis, the basic homogeneity of the late Middle Pleistocene LFAs is confirmed. The occurrence of a new sub-

species of fallow deer and the sporadic presence of *Equus hydruntinus* and *Mammuthus* ex gr. *M. cosarichus*-*M. primigenius*, seems to be of minor importance than the change in composition due to taphonomic, ecological or random factors. In fact, the results achieved by the analysis of subspecies do not allow any separation between LFAs belonging to Torre in Pietra and Vitinia FUs.

The results of the analysis based on the subspecies confirm those previously obtained in the case of the oldest LFAs are considered (Fig. 4). Nevertheless, some differences can be detected with respect to latest Villafranchian and Galerian faunal assemblages. The latest Early Pleistocene LFAs belonging to Farneta, Pirro and Colle Curti FUs group together; moreover, a minor gap takes place between the latest Villafranchian and early Galerian. This confirms the transitional character of these faunas and the more advanced evolutive degree of the early Galerian LFAs. The basic homogeneity of the middle Galerian assemblages is put in evidence because all of these LFAs fall in a single cluster, more related to the Aurelian than to Villafranchian+early Galerian LFAs. Moreover, Visogliano LFA groups with the late Galerian LFAs.

The accumulated information from multivariate analyses of both similarity and parsimony-based methods, suggests an enough good agreement to separate groups of highest hierarchical rank. The main difference between the results of the two analytic methods concerns the relationship among the LFAs belonging to Traversa FU, the Ruscinian and the middle Villafranchian MAs. Only the increase in the knowledge of the Italian Ruscinian mammal faunas would shed light on this problem. The subdivisions into lower hierarchical rank do not substantially differ.

Conclusions

The multivariate analysis of Italian large mammal LFAs, from the latest Miocene to the Middle Pleistocene, have been made using two different methodological approaches. The first one is the similarity approach, based on the common presence of taxa; that allows to recognise faunal complexes having certain taxonomic homogeneity, but it does not permit a temporal ordering of localities. The second is a parsimony based method, that uses the various relationships between FAs and LAEs, in which the presence of concurrent taxa is not relevant.

Despite the different conceptual basis of the two methods, the obtained results basically agree. Three main groups can be detected, corresponding to Turolian+Ruscinian (Late Miocene and Early Pleistocene, according to the results of appearance event ordination analysis) or Turolian+ Ruscinian+early Villafranchian (according to similarity analysis), (early?) Villafranchian+early Galerian (Middle Pliocene and

Early Pleistocene) and middle-late Galerian+early-middle Aurelian LFAs (Fig. 3).

In agreement with the results of both multivariate analysis, a gap between the Early Pleistocene LFAs and the Middle Pleistocene LFAs clearly separates the two groups of faunas. This distinction is representative of the faunal renewal that took place at the end of the Early Pleistocene and the beginning of the Middle Pleistocene. As pointed out by several authors, this faunal turnover, either due to local evolution of pre-existing taxa or by immigrations from Asia and/or Central Europe, is related to important changes in the cyclicity of climate fluctuations and to variations in the paleoenvironmental conditions.

In contrast, the analysis results differ in regard to the importance of faunal renewals related to paleo-community reorganisations, mainly depending on concurrent environmental change and major pulse in the late Neogene glacial trend. The lack of typical Ruscinian mammal assemblages may have played an important role. So, the position of the LFAs belonging the Triversa FU mainly depends either on the persistence of «Ruscinian» taxa (similarity analysis) or on FAEs/LAEs relationships (parsimony-based analysis).

According to the similarity analysis results, the faunal renewal, that took place in coincidence with the marked cooling event taking place about 2.6/2.5 Ma, seems to be more important than the faunal turnover correlated with the climatic cooling that took place at 3.2/3.1 Ma. On the contrary, according to results of the parsimony analysis, this late event should be more relevant.

The existence of large groups of lower hierarchical rank and of minor gaps in the LFAs ordination resulting from both analyses, suggests the existence of biochrons maybe of intermediate degree among «Age» and «FU». Nevertheless, according to and comparing the results of the multivariate analysis, it seems to be very difficult to detect a clear and constant correspondence among the clusters of the lowest rank and FUs as till now proposed for Italian large mammal assemblages.

However, in agreement with our results, it seems logical, to assign the three (or four?) main groups to biochrons of highest hierarchical rank, instead of MA (while, waiting for more available data, the biochronological attribution of LFAs belonging to Triversa FU remains doubtful). Moreover, the transitional character of the latest Early Pleistocene LFAs seems to be confirmed as well as their close relationships with other

Villafranchian fauna. With respect to the younger faunas, the Middle Pleistocene LFAs show a quite good homogeneity and the distance between early Middle Pleistocene (Galerian) and late Middle Pleistocene (Aurelian) LFAs appears to be less important than the distance between latest Early Pleistocene and Middle Pleistocene LFAs.

These results confirm that local biochronological sequences erected on the basis of classic criteria (presence/absence of particular taxa and faunal turnovers, "evolutionary stage" there in given taxon/taxa and "evolutionary sequences") should be useful to produce very detailed local biochronological subdivisions. However, where the bioevent sequence and the subdivision in biochronological units become too much detailed, it becomes difficult to define faunal complexes available to make correlations.

In conclusion, the application of multivariate analysis to compare Italian large mammal LFAs, from the latest Miocene to the Middle Pleistocene, shows a good resolution in the definition of groups of highest hierarchical rank. Some problems are related to the interpretation and biochronological definition of lower hierarchical rank groups. The most important can be summarised as follows: the disagreement in taxonomical identification of some taxa and/or impossibility of specific attribution to specimens (the effective richness of a given LFA may be reduced; and some data useful for the multivariate analysis are lost); the impossibility to have a succession of LFAs distributed during the time without temporal gaps; the lack of geochronological (radiometric, magnetostratigraphic etc) data for the main part of LFAs; the low richness of some LFAs, depending on taphonomic, ecological or random factors, which should be the only representative of a given span of time.

However, the results of both multivariate analyses confirm that the main faunal renewals correspond to the main climatic changes occurring at the beginning of the Middle Pliocene and of the Middle Pleistocene. Any way, the multivariate approach should provide an useful tool in order to define biochronological units, especially in the preliminary recognition of succession of non overlapping, ecologically adjusted assemblages of taxa, living together in a given space and time.

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SOMMARIO

La biocronologia delle faune a mammiferi plio-pleistoceniche italiane si basa sul riconoscimento di unità faunistiche, definite, più che su singoli eventi di comparsa/scomparsa, sulla base di ben definite e caratteristiche associazioni di specie. Tali unità possono quindi essere considerate all'incirca equivalenti a cenozone. La scoperta di nuovi giacimenti e l'affinarsi delle conoscenze ha permesso la definizione di una scala biocronologica di dettaglio che risulta di grande utilità nel caso si considerino faune italiane, ma diventa di difficile utilizzo quando si vogliono effettuare correlazioni a più larga scala. Le metodologie di analisi multivariate possono costituire degli utili strumenti per studi

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biocronologici in una prima fase di ordinamento temporale di faune locali e di definizione di gruppi di faune affini, le quali siano individuabili come insiemi ecologicamente compatibili di taxa, convissuti su un definito areale nello stesso intervallo temporale.

Due diversi approcci metodologici sono stati utilizzati per l'analisi multivariata di alcune faune a grandi mammiferi italiane, dal Miocene superiore al Pleistocene medio, l'analisi di somiglianza e l'ordinamento dei bioeventi. Il primo metodo si basa sulla presenza di taxa comuni e permette il raggruppamento di faune aventi una certa omogeneità tassonomica, ma non permette di definire un ordine cronologico. Il secondo si basa sul principio della parsimonia e valuta le varie relazioni fra bioeventi (FAEs e LAEs), in questo caso la presenza di taxa comuni non viene valutata.

Malgrado la differente concezione di base, i due metodi hanno dato risultati ampiamente confrontabili. Sulla base dei risultati ottenuti, nell'ambito delle faune esaminate, è stato possibile riconoscere tre gruppi principali. Il primo corrisponde all'insieme delle faune delle Eta' a Mammiferi Turoliano e Rusciniario (nel caso dell'analisi basata sull'ordinamento degli eventi) oppure Turoliano, Rusciniario e Villafranchiano inferiore (nel caso dell'analisi di somiglianza); il secondo alle faune del restante Villafranchiano e del Galeriano inferiore; il terzo all'insieme delle faune del Galeriano medio e superiore e dell'Aureliano inferiore e medio.

In base ai risultati di entrambi i tipi di analisi, le faune del Pleistocene inferiore costituiscono un gruppo chiaramente separato da quello delle faune del Pleistocene medio, in accordo con il significativo rinnovo faunistico che si realizza alla fine del Pleistocene inferiore e agli inizi del Pleistocene medio in concomitanza del mutare delle condizio-

ni climatiche globali e delle caratteristiche paleoambientali.

I risultati sono invece leggermente dissimili per quel che concerne la valutazione del rinnovo faunistico che avviene in concomitanza delle variazioni ambientali determinate dalle crisi climatiche del tardo Miocene. Ciò è da porre in relazione con la mancanza di una adeguata documentazione di faune del Rusciniario che fa variare l'inserimento delle faune appartenenti all'unità faunistica di Triverna a seconda del peso che viene dato o alle presenze dei taxa o a FOD e LOD. La separazione in gruppi distinti delle faune del Rusciniario e del Villafranchiano inferiore corrisponde ai rinnovi faunistici che si verificano in corrispondenza delle crisi climatiche dei 3.3/3.2 e 2.7/2.5 Ma.

Entrambe le analisi evidenziano da un lato il carattere di transizione delle faune del tardo Pleistocene inferiore, che accomuna le faune tardo Villafranchiane e quelle del Galeriano inferiore, e dall'altro la sostanziale omogeneità delle faune del Pleistocene medio superiore, che non consente una chiara distinzione tra faune dell'Aureliano inferiore e medio.

Confrontando i risultati delle analisi multivariate con gli schemi biocronologici proposti per le faune italiane, si può osservare una buona corrispondenza nella definizione delle categorie di rango superiore, assimilabili ad Età a Mammiferi, che vengono a costituire complessi faunistici ben caratterizzati, ed alla loro suddivisione in gruppi di rango intermedio, mentre vari problemi si incontrano nell'interpretazione e nella definizione delle categorie di rango inferiore assimilabili ad unità faunistiche.

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APPENDIX

GRAVITELLI

Seguenza, 1902, 1907; Delson, 1975; Kotsakis, 1986; Kotsakis *et al.*, 1997; Made, 1999; Rook, 1999; Rook *et al.*, 1999; Torre *et al.*, 2000.

Age: late Turolian, MN13 (Late Miocene).

Large Mammal Fauna: *Mesopithecus* sp. (aff. ?*Mesopithecus monspessulanus*), Viverridae indet., *Thalassictis hyaenoides*, *Metailurus parvulus*, *Mammut (Zygodon) turicensis*, *Mammut (Zygodon) borsoni*, ?*Dicerorhinus* sp., *Diceros* cf. *D. pachygnathus*, *Microstonyx major erymanthius*, *Hexaprotodon siculus*, Reduncini indet., ? *Gazella deperdita*, ?*Parabos* sp.

Observations: we hypothesise the occurrence of a transitional form to *M. monspessulanus* according to small size of the Gravitelli specimens.

According to Made (1999), the European hippopotamus species previously attributed to *Hexaprotodon* genus, belong to the same species, so the name having the precedence is *Hippopotamus pantanelli* Jolaud, 1920; *Hippopotamus siculus* Hoojer, 1946 should be a younger synonym.

New data relative to Miocene Mammals assemblage of Calabria (Kotsakis *et al.*, 1997; Torre *et al.*, 2000) confirms the African affinities of the faunal assemblages from Siculo-Calabrian province.

After Torre *et al.* (2000), the suidae from Gravitelli should be related to *Nyanzachoerus devauxi*, taking in to account the occurrence of a very similar form in the Miocene of Calabria.

BACCINELLO

Hurzeler & Engesser, 1976; Rook, 1989, 1992, 1999; Rook *et al.*, 1991, 1999; Rook & Rustioni, 1991; Bossio *et al.*, 1993; Benvenuti *et al.*, 1994, 1999; Kotsakis *et al.*, 1997; Sarti *et al.*, 1998; Abbazzi, 2000, in press; Abbazzi & Azanza, 2000; Palombo *et al.*, in press.

Age: late Turolian, MN13 (Late Miocene).

Large Mammal Fauna: *Mesopithecus* sp. (?*M. pentelicus*), *Plesiogulo crassus*, *Viverra* sp., Hyaenidae indet., *Metailurus major*, *Amphimachairodus* ex gr. *A. giganteus*, *Tapirus* cf. *T. arvernensis*, *Hipparion* sp.1, *Hipparion crassum*, *Dicerorhinus* cf. *D. megarhinus*, *Korynochoerus provincialis*, *Tuscomeryx huerzelerii*, Cervidae indet., *Paracervulus* cf. *Paracervulus australis*, *Procapreolus loczyi*, Bovidae indet., *Parabos* sp.

Observations: The V3 mammal assemblage is correlated with MN13 zone and with the pre-intra Messinian tectonic phase on the basin of stratigraphical data (Benvenuti *et al.*, 1994, 1999). Moreover, the sedimentary succession was unconformably overlain by a capping layer of marine clays and sands belonging to *Sphaerodinellopsis* Zone (Early Pliocene age, Bossio *et al.*, 1991).

According to Rook (1999), the size of the scanty molars of *Mesopithecus* cannot allow any specific attribution.

Two small cervids are reported from Baccinello V3 by Hurzeler & Engesser (1976); later Kotsakis *et al.* (1997) mentioned the occurrence of *Procapreolus* sp. and *Paracervulus* sp., this was later tentatively attributed to *Paracervulus australis* by Palombo *et al.* (in press). According to the recent revision of the Baccinello cervids made by Abbazzi (in press), four species were recognised, three deers *Procapreolus loczyi*, *Paracervulus* cf. *P. australis*, Cervidae indet. and a representative of the Moschidae family described as *Tuscomeryx huerzelerii* (= *Moschus* sp., Rook *et al.*, 1999).

Several Late Miocene deers, belonging to Muntiacinae, Cervinae or Odocoileinae, are also similar in size to *Capreolus capreolus*. Thus, the material (one tibia) recorded from Upper Messinian deltaic sediments outcropping at Torrente Morra (Collesalveti, Pisa) (Sarti *et al.*, 1998) testifies the occurrence of a small deer, that probably corresponds to one among the deers described in Baccinello basin.

The occurrence of *Procapreolus loczyi* (reported from the Late Miocene of Hungary, Pohlig, 1911), and *Paracervulus australis* (reported from the Ruscinian of France, Dong, 1996; de Bruijn *et al.*, 1992) in Baccinello V3 confirms the connection between Tuscany and Europe.

Korynochoerus sp. is also recorded together with cf. *Parabos* and indetermined Bovidae from Velona basin (Southern Tuscany, MN13) (Rook & Ghetti, 1997; Rook *et al.*, 1999)

BRISIGHELLA, MONTICINO QUARRY

De Giuli, 1989; Engesser, 1989; Marabini & Vai, 1989; Masini & Thomas, 1989; Torre, 1989; Rook, 1990, 1992; Rook *et al.*, 1991, 1999; Kotsakis *et al.*, 1997; Sarti *et al.*, 1998; Abbazzi & Azanza, 2000.

Age: latest Turolian, MN13 (uppermost) (Late Miocene).

Large Mammal Fauna: *Mesopithecus* sp. (*M. cf. pentelicus*), *Eucyon monticiniensis*, *Mellivora bienfeldi*, *Thalassictis (Lychaena)* gr. *T. charentis*-*T. macros-*

toma, *Plioviverrops flaventinus*, «*Felis*» gr. *F. attica*-*F. christoli*, Gomphotheridae indet., *Hipparion* sp., *Dicerorhinus* cf. *D. megarhinus*, *Korynochoerus provincialis*, Ruminantia indet., *Paracervulus* cf. *P. australis*, Bovidae indet., cf. *Parabos* sp., *Samotragus occidentalis*.

Observations: The fossiliferous sediments containing the mammalian fauna unconformably overlies the structurally deformed gypsum beds of the intra-Messinian tectonic phase (Marabini & Vai, 1989). A quite more recent age than Baccinello have been already hypothesised for Brisighella, according to the more advanced characters of carnivores (Rook *et al.*, 1991) and *Apodemus* of this late locality (Engesser, 1989; Argenti, 1999). According to Rook (1999), even if the sample is very small, the size of the molar of *Mesopithecus* might be consistent with an attribution to *M. cf. M. pentelicus*.

The Brisighella fauna differs considerably from other Turolian Italian mammal assemblages. This could attest to the existence of a separated paleobioprovince connected with Eurasia (Sarti *et al.*, 1998), even if some alternative hypotheses, such as a quite different age and/or different paleoenvironmental conditions, cannot be ruled out.

CASINO

Pantanelli, 1879; Azzaroli, 1980; Alberdi & Bonadonna, 1988a; Rook, 1990, 1992; Rustioni, 1992; Bossio *et al.*, 1991, 1993; Kotsakis *et al.*, 1997; Rook *et al.*, 1999; Abbazzi & Azanza, 2000.

Age: late Turolian, MN13 (Late Miocene).

Large Mammal Fauna: *Mesopithecus pentelicus*, *Eucyon* sp., *Thalassictis* cf. *T. hipparionum*, *Tapirus arvernensis*, *Hipparion crassum*, *Korynochoerus provincialis*, *Hexaprotodon pantanelli*, *Paracervulus* cf. *P. australis*, *Parabos* sp.

Observations: The fossiliferous level of Casino locality can be referred to Upper Miocene. In fact it post-dates the infra-Messinian tectonic phase and it is unconformably overlain by marine deposits belonging to *Sphaeroidinellopsis semilunula* s.l. Zone (early Lower Pliocene, Bossio *et al.*, 1991, 1993). The scanty mammal remains are referred to the uppermost MN 13 biozone, as should be confirmed by the occurrence of a suid closely related to the Ruscinian species *Sus minor*. Actually, the taxonomical attribution of this suid is doubtful; in fact in the faunal list given by Rook *et al.* (1999) *Korynochoerus provincialis* is reported.

Rook (1999) does not agree with Delson's (1975) opinion that the molars of *Mesopithecus* should repre-

sent a transitional form from *Mesopithecus pentelicus* to *Mesopithecus monspessulanus* because "morphologically and dimensionally the entire sample from Casino cannot be distinguished by the *M. pentelicus* sample from Pikermi".

VAL DI PUGNA

Cappellini, 1872; De Giuli *et al.*, 1984; Azzaroli *et al.*, 1988a; Kotsakis *et al.*, 1997.

Age: Ruscinian, MN15 (Early Pliocene).

Large Mammal Fauna: *Dicerorhinus megarhinus*, *Sus minor* (= *Sus arvernensis*), *Alephis lyrix*.

Observations: The mammals remains coming from marine deposits, which would be referred to *Globorotalia punctolata* zone (*pro parte*), after the opinion of De Giuli *et al.* (1984).

PONZANO DI MAGRA

Azzaroli, 1980; Federici, 1973; Kotsakis, 1986; Rustioni, 1992.

Age: ?late Ruscinian/?early Villafranchian, ?MN15/?MN16a.

Large Mammal Fauna: *Ursus* cf. *Ursus minimus*, *Tapirus arvernensis*, *Stephanorhinus jeanvireti*, *Sus* cf. *Sus minor*.

Observations: On the basis of faunal list, the age of this small fauna is doubtful: late Ruscinian or early Villafranchian.

TRIVERSA

Lindsay *et al.*, 1980, 1995; Azzaroli *et al.*, 1988a, b; Benvenuti *et al.*, 1995; Carraro *et al.*, 1996; Albanelli *et al.*, 1997; Gliozzi *et al.*, 1997 and references there in.

Age: early Villafranchian, Triversa FU, MN16a zone (Middle Pliocene).

Large Mammal Fauna: *Mesopithecus monspessulanus*, *Baranogale helbingi*, *Enhydriactis ardea*, *Megaviverra appennina*, *Viverra pepraxi*, *Ursus minimus*, *Chasmaportetes lunensis*, *Acinonyx pardinensis*, *Homotherium crenatidens*, *Parailurus hungaricus*, *Mammut* (*Zygodon*) *borsoni*, *Anancus arvernensis*, *Tapirus arvernensis*, *Stephanorhinus jeanvireti*, *Sus minor* (= *Sus arvernensis*), *Pseudodama lyra*, *Leptobos stenometopon*.

Observations: An age of about 3.2 Ma, was suggested by paleomagnetic analyses at Fornace R.D.B. (Lindsay *et al.*, 1980), taking in to account the sedimentation rate that allow to interpret the sequence as the Middle of the Gauss magnetic chron. Nevertheless, according to the Lindsay *et al.* (1995) opinion, the two intervals of reversed magnetic polarity, separated by a normal magnetozone, cannot be correlated with the Mammoth or Khaena episodes, but with the late Gilbert magnetochronozone. So, the magnetostratigraphic calibration cannot give yet a definitive place to the Triversa mammal assemblage. However, a younger age seems to better agree with the paleomagnetic, geological, palynological evidences given by the Italian localities yielding mammals remains belonging to the Triversa faunal unit (Albianelli *et al.*, 1997) and for which an age of 3.0-3.3 have been suggested.

The Triversa local fauna is actually a composite one, made by various spotted finds in the Triversa river area (Arboschio, Arondelli, Casa Crotino, Casa Cassinotta, Dusino, Fornace R.D.B., S. Paolo Solbrito). However, the remains would belonging to the same Upper Pliocene San Martino stratigraphical unit (lower complex outcropping in the Triversa area, Ambrosetti *et al.*, in Carraro *et al.*, 1996).

GAVILLE-SANTA BARBARA

Berzi, 1966; Rustioni, 1987; Masini, 1989; Torre *et al.*, 1996; Albianelli *et al.*, 1995, 1997.

Age: early Villafranchian, Triversa FU, MN16a (Middle Pliocene).

Large Mammal Fauna: *Ursus minimus*, *Mammuth (Zygodon) borsoni*, *Anancus arvernensis*, *Tapirus arvernensis*, *Stephanorhinus jeanvireti*, *Sus minor* (= *Sus arvernensis*), *Leptobos* cf. *L. stenometopon*.

Observations: Recent paleomagnetic calibration have been carried out at a long sedimentary sequence exposed in the Santa Barbara (lignitic lacustrine silty clays and sands, Meleto clays of Castelnuovo dei Sabbioni sequence). The results attest a long normal polarity interval interrupted at few meters above the fossiliferous lignite level by a reversed polarity interval (Albianelli *et al.*, 1995, 1997), which can be respectively assigned to late Gauss age and to the short Kaena event.

MONTOPOLI

De Giuli & Heintz, 1974a, b; Lindsay *et al.*, 1980; Benvenuti *et al.*, 1995; Torre, 1987; Bonadonna & Alberdi, 1987a,b; De Giuli *et al.*, 1988; Azzaroli *et al.*,

1988; Masini *et al.*, 1991, 1996; Ficarelli *et al.*, 1996; Azzaroli, 1992; Palombo, 1995; Caloi, 1997; Caloi & Palombo, 1997.

Age: early middle Villafranchian, Montopoli FU, MN 16b (late Middle Pliocene).

Large Mammal Fauna: *Nyctereutes megamastoides*, *Pachycrocuta perrieri* (= *Pliohyaena perrieri*), *Acinonyx pardinensis*, *Anancus arvernensis*, *Mammuthus (Archidiskodon) meridionalis gromovi*, *Equus livezovensis*, *Stephanorhinus jeanvireti*, *Stephanorhinus etruscus*, *Croizetoceros ramosus*, *Pseudodama lyra*, *Eucladoceros falconeri*, *Gazella borbonica*, *Leptobos stenometopon*.

Observations: The Montopoli local fauna (which is immediately above the Gauss-Matuyama boundary), as well as the Montopoli FU assemblages, have long been considered Early Villafranchian in age. Nevertheless, the marked faunal turnover which characterised the transition between Triversa and Montopoli FUs suggests to put here the early-middle Villafranchian boundary. So the Montopoli FU represents the oldest Middle Villafranchian FU.

CAVA TOPPETTI

Basilici, 1992; Abbazzi *et al.*, 1997 and references there in.

Age: middle Villafranchian, ?Costa San Giacomo FU (Latest Pliocene).

Large Mammal Fauna: cf. *Equus livezovensis*, *Stephanorhinus* cf. *S. etruscus*, *Procapreolus* sp., *Pseudodama* cf. *P. lyra*, *Leptobos* sp. (cf. *Leptobos* ex gr. *L. merlai-L. furtivus*).

Observations: This fauna was previously referred to the Montopoli FU on the basis of the occurrence of a large sized equid and a very primitive *Pseudodama*. New paleomagnetic data carried out by analysis of the sediments of Fosso Bianco Formation (underlying the paleosols of Ponte Naia Formation yielding the fossil mammals) attest a post Reunion episode age (Abbazzi *et al.*, 1997).

COLLE PARDO

Masini *et al.*, 1991, 1996; Segre, 1982; Cassoli & Segre Naldini, 1984, 2000; Gliozzi *et al.*, 1997; Caloi & Palombo, 1996, 1997.

Age: middle Villafranchian, «Saint Vallier» FU (Late Pliocene).

Large Mammal Fauna: *Nyctereutes megamastoides*, *Megantereon cultridens*, *Stephanorhinus* cf. *S. jeanvireti*, *Sus minor* (= *Sus arvernensis*), *Pseudodama lyra*, ?*Hemitragus* cf. *H. stehlini*.

Observations: Despite the scarcity of the faunal remains, this fauna was considered intermediate in age between the Montopoli and Costa San Giacomo complexes by several authors (Caloi & Palombo, 1996, 1997; Gliozzi *et al.*, 1997). According to the faunal list an attribution to an older faunal complex (?Montopoli FU) cannot be ruled out. After Cassoli & Segre Naldini (2000) the Colle Pardo fossiliferous levels should be older than the Costa San Giacomo ones.

VALLE CATENACCIO

Cassoli & Segre Naldini, 1984, 2000; Masini *et al.*, 1991, 1996; Moullé & Echassoux, 2000.

Age: middle Villafranchian, ? Costa San Giacomo FU (Latest Pliocene).

Large Mammal Fauna: *Pachyrocata perrieri* (= *Pliohyaena perrieri*), *Mammuhus* (*Archidiskodon*) *meridionalis*, *Equus stenorhis*, cf. *Pseudodama lyra*, cf. *Eucladoceros tegulensis*, *Gazella borbonica*.

Observations: The remains coming from Valle Catenaccio are very scanty. So, on the basis of the faunal list it is difficult to attribute this small fauna to the «Saint Vallier» or Costa San Giacomo FUs. An attribution to the first can be hypothesised on the basis of correlation between the fossiliferous levels of Valle del Catenaccio and Costa San Giacomo.

COSTA SAN GIACOMO

Biddittu *et al.*, 1979; Masini, 1989; Segre, 1982, 1993; Cassoli & Segre Naldini, 1984, 1993, 2000; Masini *et al.*, 1991, 1996; Rook & Torre, 1996; Alberdi *et al.*, 1997; Gliozzi *et al.*, 1997; Moullé & Echassoux, 2000.

Age: late middle Villafranchian, Costa San Giacomo FU (Latest Pliocene).

Large Mammal Fauna: *Macaca sylvanus florentinus*, cf. *Vulpes alopecoides*, *Canis etruscus*, *Chasmaportetes lunensis*, ?*Acinonyx pardinensis*, *Anancus arvernensis*, *Mammuthus* (*Archidiskodon*) *meridionalis*, *Equus stenorhis*, *Stephanorhinus* cf. *S. etruscus*, *Sus* cf. *S. strozzi*, *Pseudodama* cf. *P. lyra*, ?*Croizetoceros ramosus*, *Eucladoceros tegulensis*, *Gazella borbonica*, *Gazellospira torticornis*, *Leptobos* ex gr. *L. merlai-L. furtivus*, *Gallogoral meneghini*.

Observations: Some scanty remains belonging to a medium-sized cervid have been referred to *Croizetoceros ramosus* by Moullé & Echassoux (unpublished list, 2000); in Italy, this species lastly occurs in the Colle Pardo FU (Gliozzi *et al.*, 1997).

QUERCIA

Masini *et al.*, 1994

Age: ? (Latest Pliocene), ? Costa San Giacomo FU.

Large Mammal Fauna: *Canis etruscus*, *Anancus arvernensis*, *Stephanorhinus etruscus*, ?*Sus strozzi*, ?*Pseudodama nestii*, *Leptobos etruscus*.

Observations: The fauna comes from levels outcropping in the Olivola-Aulla basin. The occurrence of *Anancus arvernensis* suggests an age older than mammal faunas belonging to Olivola FU. According to Masini *et al.* (1994), this fauna should be attributed to Costa San Giacomo FU.

OLIVOLA

Azzaroli, 1977a; De Giuli *et al.*, 1984; Torre, 1987; Masini *et al.*, 1991, 1996; Ficarelli *et al.*, 1996; Azzaroli, 1992; Azzaroli & Mazza, 1992; Torre *et al.*, 1993, 1996; Caloi, 1997; Gliozzi *et al.*, 1997 and references there in.

Age: early late Villafranchian, Olivola FU (Latest Pliocene).

Large Mammal Fauna: *Canis etruscus*, *Enhydriactis ardea*, *Ursus etruscus*, *Chasmaportetes lunensis*, *Pachyrocata brevirostris*, ?*Felis lunensis*, *Lynx issiodorensis*, *Panthera* ex gr. *P. gombaszogensis*, *Homotherium crenatidens*, *Megantereon cultridens*, *Mammuthus* (*Archidiskodon*) *meridionalis meridionalis*, *Equus stenorhis* (= *E. stenorhis olivolanus* in Caloi, 1997), *Stephanorhinus etruscus*, *Sus strozzi*, *Pseudodama nestii*, *Eucladoceros dicranios olivolanus*, *Leptobos etruscus*, *Leptobos* ex gr. *L. merlai-L. furtivus*, *Gallogoral meneghini*, *Procampoceras brivatense*.

Observations: The Olivola fossiliferous level, holding the most important local fauna of the beginning of the Late Villafranchian, have to locate in the Olduvai magnetozone before the β event, so the deposit is correlatable with the Latest Pliocene. Previously the Olivola fauna has been considered younger on the basis of the correlation with the Matassino local fauna, that is calibrated with this paleomagnetic event (Torre *et al.*, 1993, 1996). Recently a new fauna has been discovered in the upper Valdarno at Poggio Rosso, in the

same stratigraphic position as the Matassino one (Gliozzi *et al.*, 1997). In this very rich fauna, both *Canis arnensis* and *Canis etruscus* occur. Accordingly, the Poggio Rosso fauna should either occupy an intermediate position between the Olivola and Tasso FUs, or it belongs to the later. Consequently, for Olivola LFA a Latest Pliocene age can be inferred.

UPPER VALDARNO I (ARGILLE DI FIGLINE BEDS)

Masini *et al.*, 1991, 1994, 1996; Albanelli *et al.*, 1995, 1997; Caloi, 1997; Gliozzi *et al.*, 1997.

Age: early late Villafranchian, ?Olivola FU.

Large Mammal Fauna: *Canis etruscus*, *Ursus etruscus*, *Pachycrocuta brevirostris*, *Lynx issiodorensis*, *Homotherium crenatidens*, *Megantereon cultridens*, *Mammuthus (Archidiskodon) meridionalis meridionalis*, *Equus stenonis* (= *E. stenonis olivolanus* in Caloi, 1997), *Stephanorhinus etruscus*, *Sus strozzii*, *Pseudodama nestii*, *Eucladoceros dicranios*, *Leptobos etruscus*, *Leptobos ex gr. L. merlai-L. furtivus*, *Gallogoral meneghini*, *Procambioceras brivatense*.

Observations: Several mammal remains coming from Argille di Figline levels (second lacustrine phase, Montevarchi «group», of upper Valdarno basin, Azzaroli & Lazzeri, 1977, Ascione Formation, Abbate, 1983, from which the Matassino fauna comes to) have been attributed to the Olivola FU. The composite faunal list should confirm this attribution. Nevertheless, according to the new evidences given by Poggio Rosso assemblage (Gliozzi *et al.*, 1997), a different attribution cannot be ruled out.

MATASSINO

De Giuli, 1972; Masini *et al.*, 1991, 1994, 1996; Torre *et al.*, 1993, 1996; Gliozzi *et al.*, 1997; Albanelli *et al.*, 1997.

Age: early late Villafranchian, ? Tasso FU (early Early Pleistocene).

Large Mammal Fauna: *Canis etruscus*, *Mammuthus (Archidiskodon) meridionalis meridionalis*, *Equus stenonis* s.s., *Sus strozzii*, *Pseudodama nestii*, *Eucladoceros dicranios/E. ctenoides*, *Leptobos etruscus*.

Observations: According to new evidences given by Poggio Rosso fauna (Gliozzi *et al.*, 1997), the previous attribution to Olivola FU cannot be maintained. Both Poggio Rosso and Matassino faunas would be included in a new FU transitional between the Olivola and the Tasso FUs.

CASA FRATA

Borselli *et al.*, 1980; De Giuli & Masini, 1983, 1987; Masini, 1989, Masini *et al.*, 1990, 1991, 1994, 1996; Ficarelli *et al.*, 1996; Torre *et al.*, 1996; Gliozzi *et al.*, 1997.

Age: early late Villafranchian, Tasso FU (early Early Pleistocene).

Large Mammal Fauna: *Canis (Xenocyon) falconeri*, *Canis etruscus*, *Martes* sp., *Ursus etruscus*, *Pachycrocuta brevirostris*, *Lynx issiodorensis*, *Homotherium crenatidens*, *Mammuthus (Archidiskodon) meridionalis meridionalis*, *Equus stehlini*, *Stephanorhinus etruscus*, *Sus strozzii*, *Pseudodama nestii*, *Eucladoceros dicranios*, ?*Leptobos vallisarni*, *Leptobos* sp. (= *Leptobos* aff. *Leptobos merlai-L. furtivus* in Masini *et al.*, 1990, 1991), *Praeovibos* sp.

Observations: According to Masini *et al.* (1990, 1991) also *Acinonyx pardinensis* occurs in the site. The presence in the Tasso FU of leptobovines belonging to the group of *Leptobos merlai-L. furtivus* (cf. Gliozzi *et al.*, 1997) and of *Canis etruscus* (Torre *et al.*, 1996), is not sure.

UPPER VALDARNO (TASSO SANDS)

Masini *et al.*, 1991, 1994, 1996; Albanelli *et al.*, 1995, 1997.

Age: early late Villafranchian, Tasso FU (early Early Pleistocene).

Large Mammal Fauna: *Macaca sylvanus florentinus*, *Canis (Xenocyon) falconeri*, *Canis arnensis*, *Martes* sp., *Pannonictis nestii*, *Ursus etruscus*, *Pachycrocuta brevirostris*, *Lynx issiodorensis*, *Panthera* ex gr. *P. gombaszoegensis*, *Homotherium crenatidens*, *Megantereon cultridens*, *Mammuthus (Archidiskodon) meridionalis meridionalis*, *Equus stenonis*, *Equus stehlini*, *Stephanorhinus etruscus*, *Sus strozzii*, *Hippopotamus* ex gr. *H. antiquus*, *Pseudodama nestii*, *Eucladoceros dicranios/E. ctenoides*, *Leptobos etruscus*, *Leptobos vallisarni*.

Observations: Several spotted remains and some not very rich local fauna (Il Tasso, Casa Inferno etc) were recorded from the same stratigraphic level of Casa Frata, belonging to the second lacustrine phase of upper Valdarno basin sequence (Montevarchi succession, Tasso sands).

TIBER BASIN

Ambrosetti *et al.*, 1995; Sardella *et al.*, 1995; Abbazzi *et al.*, 1997.

Age: late Villafranchian, ?Tasso FU (Early Pleistocene).

Large Mammal Fauna: *Pachycrocuta brevirostris*, *Megantereon cultridens*, *Mammuthus (Archidiskodon) meridionalis*, *Equus stenonis*, *Stephanorhinus etruscus*, *Sus strozzii*, *Pseudodama nestii*, *Eucladoceros* cf. *E. dicranios*, *Leptobos* cf. *L. vallisarni*.

Observations: Some mammal remains were recorded from several sites located in the southwestern branch of the Tiber Basin (Villa San Faustino, Colle Sant'Andrea, Colle Violino, Casale le Grotte), where the levels of S. Maria di Ciciliano Unit crop out. The occurrence of *Pseudodama nestii* together with *Leptobos* ex gr. *L. vallisarni* supports a correlation with the Tasso FU.

PANTALLA

Gentili *et al.*, 1997 and references there in.

Age: late Villafranchian (?middle Early Pleistocene).

Large Mammal Fauna: *Canis* cf. *C. etruscus*, *Lynx* cf. *L. issiodorensis*, *Panthera* cf. *P. gombaszoegensis*, *Equus* sp. (?*Equus stenonis*), *Sus* cf. *S. strozzii*, *Pseudodama* cf. *P. nestii*, *Leptobos* sp.

Observations: Fossil remains have been found within different strata: silty sands yielding a very rich fauna, and a paleosol yielding some herbivores remains. These two mammal assemblages were produced by different physical and biological processes; despite this they can be deposited in a very reduced span of time and are not different in age.

FONTANA ACETOSA

Cassoli & Segre Naldini, 1984, 1993, 2000; Masini *et al.*, 1991, 1996; Moullé & Echassoux, 2000.

Age: late Villafranchian, ? Tasso FU (Early Pleistocene).

Large Mammal Fauna: ?*Canis arnensis*, ?*Canis etruscus*, cf. *Ursus etruscus*, ?*Pachycrocuta brevirostris*, *Megantereon* cf. *M. cultridens*, *Mammuthus (Archidiskodon) meridionalis*, *Equus* cf. *E. stenonis*, *Stephanorhinus* sp. (*Stephanorhinus* aff. *S. hundschemensis* in Moullé & Echassoux, 2000), *Sus* cf. *S. strozzii*, *Hippopotamus* ex gr. *H. antiquus*, *Pseudodama nestii*, *Eucladoceros dicranios*, *Leptobos* sp., Cervini indet. (= *Crozetoceros ramosus* in Moullé & Echassoux, 2000).

Observations: According to Cassoli & Naldini Segre (1984), the sand-clay levels which have yielded the

mammal remains would be correlated with the Costa San Giacomo ones. Nevertheless, the occurrences of both *Hippopotamus* ex gr. *H. antiquus* and *Pseudodama nestii* suggests an attribution to Tasso FU.

MUGELLO

Masini, 1989; Masini *et al.*, 1994; Abbazzi *et al.*, 1995; Rook, 1996; Benvenuti *et al.*, 1998.

Age: late Villafranchian, Tasso and Farneta FUs (Early Pleistocene).

Large Mammal Fauna: *Macaca sylvanus florentinus*, *Ursus etruscus*, *Mammuthus (Archidiskodon) meridionalis vestinus*, *Stephanorhinus etruscus*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, *Sus strozzii*, *Hippopotamus* ex gr. *H. antiquus*, *Pseudodama farnetensis*, *Eucladoceros dicranios/E. ctenoides*, *Leptobos* sp., ?*Bison (Eobison) degiulii*.

Observations: According to Abbazzi *et al.* (1995), the mammal fossils found in the Mugello Basin reveal a quite complex picture. The specimens coming from the fluvio-lacustrine phase are distributed over a period including Tasso and Farneta FUs. The possibility that all taxa belong to a single assemblage intermediate in age between the Tasso and Farneta FUs. cannot be ruled out.

VAL DI CHIANA

Azzaroli, 1984; De Giuli, 1987; Torre *et al.*, 1992; Azzaroli & Mazza, 1993; Masini *et al.*, 1991, 1996; Abbazzi, 1995.

Age: late Villafranchian, Farneta FU (middle Early Pleistocene).

Large Mammal Fauna: ?*Macaca sylvanus florentina*, *Canis etruscus*, ?*Ursus etruscus*, *Homoherium crenatidens*, *Mammuthus (Archidiskodon) meridionalis vestinus*, ?*Equus stehlini*, ?*Sus strozzii*, *Pseudodama farnetensis*, *Megaceroides obscurus*, *Leptobos etruscus* (advanced form), *Leptobos vallisarni*.

Observations: The faunal list includes taxa which have been found in the sands belonging to the first fluovio-lacustrine phase of the sedimentary sequence outcropping at several localities from the Chiana river valley.

IL CROSTOLO

Ambrosetti & Cremaschi, 1976; Masini *et al.*, 1991, 1996; Abbazzi, 1995.

Age: late Villafranchian, ? Farneta FU (middle Early Pleistocene).

Large Mammal Fauna: *Canis* cf. *C. etruscus*, *Mammuthus* (*Archidiskodon*) *meridionalis vestinus*, *Stephanorhinus etruscus*, *Sus strozzii*, *Hippopotamus* ex gr. *H. antiquus*, ?*Cervalces gallicus*, ?*Megaceroides obscurus*, *Pseudodama farnetensis*.

SELVELLA

De Giuli, 1987; Azzaroli *et al.*, 1988a, b; Masini *et al.*, 1991, 1996; Abbazzi, 1995.

Age: late Villafranchian, Farneta FU (middle Early Pleistocene).

Large Mammal Fauna: *Canis etruscus*, *Lynx issiodorensis*, *Mammuthus* (*Archidiskodon*) *meridionalis*, *Equus altidens*, *Pseudodama farnetensis*, *Megaceroides obscurus*, *Leptobos* ex gr. *L. vallisarni*.

Observations: The rich fauna coming from the sands belonging to the first fluvio-lacustrine phase of sedimentary sequence outcropping in the Chiana river valley.

PIETRAFITTA

Moretti, 1949; Ambrosetti *et al.*, 1987; Masini *et al.*, 1991, 1996; Rustioni & Mazza, 1992, 1993; Mazza *et al.*, 1993; Abbazzi, 1995; Gentile *et al.*, 1996; Torre *et al.*, 1996; Ferretti, 1999.

Age: late Villafranchian, Farneta FU (middle Early Pleistocene)

Large Mammal Fauna: *Macaca sylvanus florentinus*, *Pannonictis nestii*, *Ursus etruscus*, *Panthera* ex gr. *P. gombaszoegensis*, *Mammuthus* (*Archidiskodon*) *meridionalis*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, *Pseudodama farnetensis*, *Megaceroides obscurus*, *Leptobos* ex gr. *L. vallisarni*.

Observations: The lignite deposits of Pietrafitta, that are part of the lacustrine succession of the Tavernelle basin, were deposited in a swampy area that represented a trap for several animals including elephants. According to Ferretti (1999), the Pietrafitta elephants are slightly different from typical *Mammuthus meridionalis vestinus* of Farneta FU.

PIRRO NORD

De Giuli & Torre, 1984; De Giuli *et al.*, 1987, 1990;

Masini, 1989; Masini *et al.*, 1991, 1996; Rook & Torre, 1996; Pfeifer, 1999; Rook & Sardella, 2000.

Age: latest Villafranchian, Pirro FU (late Early Pleistocene).

Large Mammal Fauna: *Canis* (*Xenocyon*) *falconeri*, *Canis* sp. aff. *C. arnensis*, *Vulpes* cf. *V. alopecoides*, *Ursus etruscus*, *Pachycrocuta brevirostris*, ?*Panthera gombaszoegensis*, *Lynx issiodorensis*, *Homotherium* aff. *H. crenatidens* (*advanced form*), *Megantereon cultridens* (*advanced form*), *Mammuthus* (*Archidiskodon*) *meridionalis*, *Equus altidens*, *Equus suessenbornensis*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, ?*Sus strozzii*, *Hippopotamus* ex gr. *H. antiquus*, *Pseudodama farnetensis* (= *Axys* sp., Pfeiffer, 1999), *Megaceroides obscurus*, *Bison* (*Eobison*) *degiuli*, *Ovibovini* indet.

Observations: According to Rook & Sardella (2000) in this fauna *Acinonyx pardinensis* possibly occurs.

CAPENA

Petronio, 1980; Masini, 1989; Di Stefano & Petronio, 1998.

Age: latest Villafranchian, Pirro FU (late Early Pleistocene).

Large Mammal Fauna: *Pseudodama* sp, *Bison* (*Eobison*) *degiuli*.

MADONNA DELLA STRADA

Maccagno, 1962a; Azzaroli, 1977c; Masini *et al.*, 1991, 1996; Caloi & Palombo, 1995.

Age: late Villafranchian, ? Farneta FU (late Early Pleistocene).

Large Mammal Fauna: *Mammuthus meridionalis vestinus*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, *Hippopotamus* ex gr. *H. antiquus*, ?*Megaceroides obscurus*.

Observations: On the basis of the provisional faunal list, it is difficult to assign the Madonna della Strada fauna to the Farneta or to the following Pirro FU. Moreover, only the elephants skeleton was analytically studied. A revision of fauna would be necessary.

COLLE CURTI

Borselli *et al.*, 1988; Ficarelli & Mazza, 1990; Ficarelli *et al.*, 1990; Ficarelli & Silvestrini, 1991;

Masini *et al.*, 1991, 1996; Masini & Santini, 1991; Rook, 1994; Rook & Torre, 1996; Coltorti *et al.*, 1998; Abbazzi *et al.*, 1998.

Age: early Galerian, Colle Curti FU (latest Early Pleistocene)

Large Mammal Fauna: *Canis (Xenocyon) ex gr. C. falconeri*, *Canis* sp. aff. *C. arnensis*, *Ursus* sp., Hyaenidae, *Mammuthus (Archidiskodon) meridionalis*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, *Hippopotamus ex gr. H. antiquus*, *Pseudodama* sp., *Megaceroides verticornis*.

Observations: The mammal fauna of Colle Curti (collected in clay layers where the Jaramillo paleomagnetic event was recognised), has been the object of several studies. Recently, the arvicolid fauna of this site have been revised (Abbazzi *et al.*, 1988) and the occurrence of a very advanced *Microtus (Allophaiomys)* sp., linked to the *Microtus oconomus* group, (previously related to *Microtus (Allophaiomys)* gr. *ruffoi*) have been detected, together with *Pliomys lenki*, a common species in the mammals assemblages of middle Galerian/late Biharian. This fact confirms the relative modern character of Colle Curti mammal assemblage in comparison with the typical late Villafranchian ones.

IMOLA

Azzaroli & Berzi, 1972; Azzaroli, 1977c; Masini *et al.*, 1991, 1996; Caloi & Palombo, 1990; Caloi, 1995; Ferretti, 1997, 1999.

Age: ?early Galerian.

Large Mammal Fauna: *Mammuthus (Archidiskodon) meridionalis*, ?*Equus altidens*, cf. *Stephanorhinus hundsheimensis*, *Hippopotamus ex gr. H. antiquus*, *Pseudodama* sp., *Megaceroides verticornis*, *Leptobos ex gr. L. vallisarni*.

Observations: The elephant molars of Imola show more advanced characters than the typical *M. meridionalis vestinus*, being hypsodont and having a higher lamellar frequency. Azzaroli (1977) considers it near to *Mammuthus meridionalis cromerensis*. According to Ferretti (1999), the elephant material from Imola, referred by the author to *Mammuthus* cf. *M. meridionalis*, does not belong to the same group as *M. meridionalis vestinus*. As already known, the younger southern elephants from Italy have to be referred to the endemic lineage characterised by very large size, specialised skull and quite primitive molar characters. In other European localities, as well as Israele (Oubeidieh, Beden, 1986) during late Early Pleistocene and

the earliest Middle Pleistocene, various *M. meridionalis* specimens were known that display advanced molar character. Some authors have regarded it as separate subspecies (Palombo, 1995; Ferretti, 1999 and references there in) that are all characterised by very high hypsodonty index and thinly folded enamel. At the end of the Early Pleistocene, these elephants have widely spread in Europe and possibly they also reached the Italian peninsula. In the case of isolated finds, as the case of Imola specimens, it is very difficult to distinguish this latest representative of *M. meridionalis* from the earliest *M. trogontherii*. Despite this difficulty, the Imola specimens should be tentatively referred to *M. meridionalis*, even if an attribution to *M. trogontherii* cannot be ruled out.

REDICICOLI

Blanc, 1955; Caloi & Palombo, 1988, 1995, 1996, 1997; Sardella, 1994; Di Stefano *et al.*, 1998.

Age: early Galerian (Colle Curti FU).

Large Mammal Fauna: Hyaenidae indet., *Mammuthus (Archidiskodon) meridionalis*, *Equus altidens*, *Stephanorhinus hundsheimensis*, *Hippopotamus ex gr. H. antiquus*, *Pseudodama* sp., Megacerini indet., ?*Bison* cf. *B. (Eobison) degiuli*, *Bison* sp. aff. *B. schoetensacki*.

Observations: The mammal remains were referred to the Colle Curti FU by Caloi & Palombo (1995, 1996, 1997). Recently, Di Stefano *et al.* (1998) do not agree with this attribution and, on the basis of the faunal list given by Caloi & Palombo, hypothesise the existence of two different faunal assemblages belonging respectively to the Pirro FU (characterised by the presence of *Bison degiuli*, *Equus* aff. *Equus altidens*, *Mammuthus meridionalis* ssp) and Isernia FU (*sensu* Petronio & Sardella, 1999), characterised by the presence of *Megaceroides* aff. *M. solilhacus*, *Stephanorhinus hundsheimensis*, *Bison schoetensacki*. Actually, the mammal remains come from a single gravel level previously outcropping at Redicicoli quarry, as displayed by A.C. Blanc unpublished data. Moreover, the presence of a large sized cervid with slender metacarpal, is only indicative of ecological features, because slender limbs seem to have characterised different large cervid taxa of Europe in late Early Pleistocene (for instance *Eucladoceros giuli* from Untermassfeld (Kahlke, 1997) and *Megaceroides* aff. *M. solilhacus* from Venta Micena (Menéndez, 1987), that exhibit a very different morphology of antlers), as well as some other large cervids of doubtful taxonomic position, that have a rather similar geological age (for instance «*Ortogonoceros*» sp. from Akalkalaki (Vekua, 1987), and *Megaceros* sp. from Oubeidieh (Geraads, 1986).

Moreover, the larger bovid from Redicicoli quarry is not represented by typical *Bison schoetensacki*, but by a related form and the scanty remains identified as *Bison degiuli* are quite different from those from Pirro Nord and Capena (Palombo, unpublished data).

MONTE TENDA

Masini *et al.*, 1991, 1996; Bon *et al.*, 1991; Caloi & Palombo, 1991; Ferretti, 1999.

Age: middle Galerian (Slivia FU) (early Middle Pleistocene, OIS 24?).

Large Mammal Fauna: *Canis* sp. aff. *C. arnensis*, *Mammuthus* (*Mammuthus*) *trogotherii*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus suessenbornensis*, *Cervus elaphus acoronatus*.

Observations: The morphological and biometrical characters of *Mammuthus* remains do not rule out a possible attribution to a very advanced southern elephant, as hypothesised by Ferretti (1999); Bon *et al.* (1991) report «*Archiskodon meridionalis cromerensis*». Moreover, according to Ferretti (1999), the presence of *Elephas* (*Palaeoloxodon*) *antiquus* is not sure.

SLIVIA

Ambrosetti *et al.*, 1979; Caloi & Palombo, 1990; Masini *et al.*, 1991, 1996; Bon *et al.*, 1991, 1992; Caloi, 1997.

Age: middle Galerian (Slivia FU) (early Middle Pleistocene, OIS 24?).

Large Mammal Fauna: cf. *Meles meles*, *Canis* sp. aff. *C. arnensis*, *Ursus deningeri*, *Pachycrocuta brevirostris*, *Panthera* ex gr. *P. gombaszoegensis*, *Homotherium* ex gr. *H. latidens*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus altidens* s.s., *Stephanorhinus* sp., *Stephanorhinus hemitoechus*, *Stephanorhinus* cf. *S. hundsheimensis*, *Sus scrofa*, *Hippopotamus* ex gr. *H. antiquus*, ?*Pseudodama* sp./?*Dama* sp., *Cervus elaphus*, Megacerini gen. et spec. indet., *Bison* cf. *B. schoetensacki*.

Observations: After the revision of the material kept in the Museo Civico di Storia Naturale di Trieste, made by Bon *et al.* (1992), also *Equus* cf. *E. ferus* occurs. The jugal fragment of hippopotamus is here tentatively reported to *Hippopotamus* ex gr. *H. antiquus* on the basis of the biochronology attribution of the fauna.

On the basis of the *Mimomys savini* occurrence and of the survival some Villafranchian carnivore, Slivia LFA was generally considered as representative of the oldest Middle Galerian FU (*sensu* Gliozzi *et al.*, 1997).

Nevertheless, taking into account the doubtful identification of main herbivores coming from Slivia local fauna, as well as the scanty knowledge about carnivores and micromammals belonging to Ponte Galeria FU (*sensu* Petronio & Sardella, 1999), the possibility that Slivia and Ponte Galeria assemblages belong to the same FU cannot be ruled out (Palombo, in press).

VALDEMINO

Masini *et al.*, 1991; Sala *et al.*, 1992; Gliozzi *et al.*, 1997; Nocchi & Sala, 1997.

Age: Middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997).

Large Mammal Fauna: *Macaca sylvanus sylvanus*, *Ursus* sp., *Canis* cf. *C. mosbachensis*, *Lynx* sp. cf. *L. spelaea*, *Panthera pardus*, ?*Homotherium ladidens* (= *Homotherium crenatidens* in Masini *et al.*, 1991), *Mammuthus trogotherii*, *Stephanorhinus* cf. *S. kichbergensis*, *Sus scrofa*, *Cervus* aff. *C. elaphus*, *Capreolus capreolus*, *Bos primigenius*.

Observations: The mammal assemblage of Valdemino cave, possibly belongs to Isernia FU, but can be referred to a different climatic phase than the Isernia local fauna.

PONTE GALERIA

Ambrosetti, 1867; Caloi & Palombo, 1980a, 1986, 1988; Caloi *et al.*, 1983; Capasso Barbato & Petronio, 1986; Petronio, 1986, 1988; Masini *et al.*, 1991, 1996; Sardella, 1994; Petronio & Sardella, 1998, 1999.

Age: middle Galerian (Ponte Galeria FU, *sensu* Petronio & Sardella, 1999; early Middle Pleistocene).

Large Mammal Fauna: ?*Mammuthus* (*Archidiskodon*) *meridionalis*, *Mammuthus* (*Mammuthus*) *trogotherii*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus altidens*, ?*Equus ferus*, *Stephanorhinus hundsheimensis*, *Hippopotamus* ex gr. *H. antiquus*, *Pseudodama* sp., *Cervus elaphus acoronatus*, *Megaceroides verticornis*, *Megaloceros savini*, *Bos galerianus*, ?*Bos primigenius*.

Observations: In the Ponte Galeria fauna also *Equus "caballus"* (Vitinia, Ponte Galeria Formation gravels, Caloi *et al.* 1983) was reported, based on a metacarpal; nevertheless the belonging of this specimens to the "current bedding gravels" of Ponte Galeria Formation is not completely sure. Some large bovine remains, recorded in the "current bedding gravels" of Ponte Galeria Formation, have been attributed to *Bos primigenius* by some authors. Moreover, recently Petronio

& Sardella (1998) have identified a new species of bovid, *Bos galerianus*, on the basis of skull remains found in the same levels of this Formation. The authors do not agree with the previous attribution to *Bos primigenius* of bovine postcranial elements found at Ponte Galeria and at other Middle Galerian LFAs. The authors consider *Bos galerianus* the only representative of genus *Bos* occurring in the Isernia FU.

Petronio & Sardella (1999) discussing the biochronology of the Middle Galerian faunal assemblages (*sensu* Gliozzi *et al.*, 1997) of Ponte Galeria Formation (Conato *et al.*, 1980, Malatesta & Zarlenga 1988), have proposed a new faunal unit for this mammal complex, intermediate in age between the Slivia and Isernia ones.

Actually it is very difficult to compare the spotted remains coming from the «current bedding gravels» from Ponte Galeria Formation to the anthropic assemblages of Isernia (Sala, 1983, Peretto, 1996). In the opinion of Petronio & Sardella (1999), the older age of «Ponte Galeria FU» is due to the occurrence of *Arvicola cantianus* at Isernia, as well as the occurrence of *Bos galerianus* and of *Megaloceros savini* at Ponte Galeria. The authors consider this cervid more archaic than *Megaceroides solihacus* (which in Italian fauna firstly occurs, in Isernia FU). Nevertheless, *M. solihacus* belongs to a separate lineage. In effect, a slightly older age of Ponte Galeria fauna should be hypothesised on the basis of possible persistence in this fauna of *Mammoth meridionalis* and of an advanced form of *Pseudodama* (= *Axis eurygonos*, Petronio *et al.*, 2000).

ISERNIA LA PINETA

Coltorti *et al.*, 1982, 2000; Sala, 1983, 1987, 1990; Masini *et al.*, 1991, 1996; Sala & Fortelius, 1993; Peretto, 1996; Abbazzi & Masini, 1997.

Age: middle Galerian (Isernia FU) (early Middle Pleistocene, OIS?).

Large Mammal Fauna: *Canis* sp. aff. *C. arnensis*, *Ursus deningeri*, *Panthera (Leo) fossilis*, *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus hundsheimensis*, *Sus scrofa*, *Hippopotamus* ex gr. *H. antiquus*, *Capreolus capreolus*, *Dama clactoniana*, *Cervus elaphus acoronatus*, *Megaceroides solihacus*, *Bison schoetensacki*, *Hemitragus bonali*.

Observations: Several authors do not agree with the K-Ar absolute data of 0.763 Ma obtained from reworked volcanic minerals of the piroclastic level underlying the anthropic deposit, given the presence in the fauna of the arvicolid *Arvicola cantianus*, that firstly occurs in Central Europe only later. New radiometric data seem to confirm a younger age for this fauna. Two main archeological layers have been identified, cov-

ered by cross bedded gravely sands, interlayered with tuff rich in sanidine. Sanidines have been Ar/Ar dated at 605±10ka (Coltorti *et al.*, 2000).

CESI

Borselli *et al.*, 1988; Ficarelli & Mazza, 1990; Ficarelli *et al.*, 1990, 1997; Ficarelli & Silvestrini, 1991.

Age: middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997) (OIS ?18/?16).

Large Mammal Fauna: *Homotherium* ex gr. *H. latidens*, Elephantinae gen et spec indet., *Equus* sp. cf. *E. ferus*, *Stephanorhinus hundsheimensis*, *Hippopotamus* sp. (?*Hippopotamus* ex gr. *H. antiquus*), *Dama clactoniana*, *Cervus elaphus*, *Megaceroides solihacus*, *Bison schoetensacki*.

Observations: The results of multidisciplinary studies indicate that the fossiliferous levels have been deposited during a normal paleomagnetic interval. The paleomagnetic inversion corresponding to Matuyama-Bruhnes boundary lies about 7 m below the mammal-bearing sediments.

Taking into account the age of the fauna, we tentatively refer the hippopotamus to the *H. antiquus* group, even if the very fragmentary material in poor state of preservation prevents a determination to species level (Ficarelli *et al.*, 1997).

G.R.A. KM 2 (ROME)

Caloi & Palombo, 1986; 1996, 1997.

Age: middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997).

Large Mammal Fauna: *Meles* cf. *M. meles*, *Hyaena prisca*, *Dama* cf. *D. clactoniana*, *Bos primigenius*.

Observations: The scanty remains found at G.R.A. coming from deposits slightly younger than the sands and gravels of Ponte Galeria Formation.

BORGONUOVO

Azzaroli, 1977b; Masini *et al.*, 1991.

Age: middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997).

Large Mammal Fauna: *Elephas (Palaeoloxodon) antiquus*, *Equus suessenbornensis*, *Hippopotamus* ex gr. *H. antiquus*, *Megaceroides verticornis*.

MONTE OLIVETO

Berzi, 1972; Masini *et al.*, 1991.

Age: middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997).

Large Mammal Fauna: *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Hippopotamus ex gr H. antiquus*, *Megaceroides verticornis*, *Cervus elaphus*, ? *Bos primigenius*.

Observations: The *Cervus elaphus* present in this fauna seems to be more closely related to the early Middle Pleistocene *Cervus elaphus acoronatus* than to the later *Cervus elaphus eostephanoceros* (Di Stefano & Petronio, 1993).

VISOGLIANO

Cattani *et al.*, 1991; Masini *et al.*, 1991; Gliozzi *et al.*, 1997; Abbazzi *et al.*, 2000; Tozzi *et al.*, 2000.

Age: Middle Galerian (Isernia FU *sensu* Gliozzi *et al.*, 1997) (OIS 13-12 or 11-10).

Large Mammal Fauna: *Macaca* sp., *Martes* cf. *M. martes*, *Meles* cf. *M. meles*, *Vulpes vulpes*, *Canis* cf. *C. mosbachensis*, *Crocuta crocuta*, *Ursus deningeri*, *Felis sylvestrus*, ? *Equus ferus*, *Stephanorhinus hundsheimensis*, Megacerini indet., *Capreolus capreolus*, *Dama clactoniana*, *Cervus elaphus*, Bovinae indet., *Bison* cf. *B. schoetensacki*, *Ovis ammon antiqua*.

Observations: The fauna from Visogliano, have been considered probably transitional with those of the Fontana Ranuccio FU by Gliozzi *et al.* (1997), due to the supposed first occurrence of *Bison priscus*. Recently (Abbazzi *et al.*, 2000), the bovide remains have been identified as *Bison* cf. *B. schoetensacki*. Nevertheless, the general index of anteroconid evolution measured on *Microtus* ex gr. *M. arvalis* (Abbazzi *et al.*, 2000), as well as paleoclimatic considerations and the aspect of evolutive trend of the tooth enamel of *Arvicola cantianus*, suggests a correlation with OIS 13-12 or 11-10, as confirmed by U-Th and ESR data Tozzi *et al.* (2000).

NOTARCHIRICO

Cassoli *et al.*, 1999 and references within; Philleyre *et al.*, 1999; Piperno, 1999; Rhodes & Grün, 1999.

Age: middle Galerian (?Isernia FU *sensu* Gliozzi *et al.*, 1997).

Large Mammal Fauna: *Canis* sp. aff. *C. arnensis*, *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus* sp., *Sus scrofa*, *Dama clactoniana*, *Cervus elaphus eostephanoceros*, Megacerini indet., Cervidae indet., *Bos primigenius*, *Bison schoetensacki*, Bovinae indet.

Observations: The vertebrate remains come from seven different levels, where the upper levels A and are the most extensively investigated (Cassoli *et al.*, 1999); the taxonomical composition of the assemblages of each level allows to hypothesise a similar age. Taking into account the various absolute datations (ESR, Rhodes & Grün, 1999 and thermoluminescence (Philleyre *et al.*, 1999), the possible age should be of about 0.6 Ma.

The fauna from Notarchirico displays a taxonomic composition transitional between those of the Isernia and the Fontana Ranuccio FUs.

VENOSA-LORETO

Caloi & Palombo, 1979a, b, 1980a, b; Alberdi *et al.*, 1988; Bonadonna *et al.*, 1998; Raynal *et al.*, 1998.

Age: late middle Galerian (Fontana Ranuccio FU).

Large Mammal Fauna: *Canis* sp. aff. *C. arnensis*, *Elephas (Palaeoloxodon) antiquus*, *Equus altidens* s.s., *Equus suessenbornensis*, *Stephanorhinus* sp. aff. *S. hundsheimensis*, "Dama" sp., *Megaceroides solhilacus*, *Bos primigenius*, *Bison schoetensacki*.

Observations: After Bonadonna *et al.* (1998), the volcanoclastic levels interbedded with conglomeratic beds containing mammal remains correspond to a warm and wet period of deposition ranging about from 0.6 to 0.4 Ma. The antler of *Megaceroides solhilacus* (Caloi & Palombo, 1979a) founded at Terranera should be younger.

The middle-sized cervids here provisionally attributed to «Dama» sp. must be revised.

FONTANA RANUCCIO

Biddittu *et al.*, 1979; Segre, 1982, 1984; Cassoli & Segre Naldini, 1993; Di Stefano & Petronio, 1993; Sardella, 1994; Moullé & Echassoux, 2000.

Age: late middle Galerian (Fontana Ranuccio FU) (OIS ?13/?11).

Large Mammal Fauna: ?*Macaca sylvanus florentinus*, *Cuon alpinus*, *Ursus deningeri*, *Panthera (Leo)* sp., *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus* cf. *S. hundsheimensis* (*S. hemitoechus* in Cassoli & Segre, 1993), *Sus scrofa*, *Hippopotamus*

ex gr. *H. amphibius*, Megacerini indet., *Dama clactoniana*, *Cervus elaphus eostephanoceros*, *Bos primigenius*.

Observations: According to Sardella (1994), an advanced form of *Homotherium* occurs in the fauna from Fontana Ranuccio, while this species is not present in more recent lists.

CAVA NERA MOLINARIO

Di Stefano & Petronio, 1993; Caloi & Palombo, 1995.

Age: late middle Galerian (Fontana Ranuccio FU).

Large Mammal Fauna: ?*Elephas (Palaeoloxodon) antiquus*, *Hippopotamus* ex gr. *H. amphibius*, *Cervus elaphus eostephanoceros*.

SAN ROMANO

Zanchetta *et al.*, 1998.

Age: late middle Galerian (Fontana Ranuccio FU) (OIS 13).

Large Mammal Fauna: *Elephas (Palaeoloxodon) antiquus*, *Cervus elaphus* (cf. *C. elaphus eostephanoceros*), *Dama clactoniana*.

Observations: A volcanic ash level at the top of the sedimentary sequence of San Romano was dated at about 0.5 Ma. This date was confirmed by new data obtained using fission track method on apatite grains, separated from the volcanic ash level (Zanchetta *et al.*, 1998; Bigazzi *et al.*, 2000).

LA POLLEDRARA DI CECANIBBIO

Anzidei *et al.*, 1989, 1999; Caloi & Palombo, 1995, Caloi *et al.*, 1998; Palombo *et al.*, in press b.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS ?10- 9).

Large Mammal Fauna: *Canis lupus*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus* sp., *Cervus elaphus*, *Bos primigenius*.

Observations: The site is included in the terminal series of the pyroclastic deposits of the «Sabatino» volcanic complex, up to now correlated with the Aurelia Formation (Conato *et alii*, 1980; De Rita *et al.*, 1992) and with OIS 9. Recent stratigraphical research seems to indicate an erosive contact

between the layers including La Polledrara di Ceganibbio site and the deposits of the Aurelia Formation. Therefore La Polledrara might be quite older and might be correlated with a terminal phase of OIS 10 (Anzidei *et al.*, 1999). Nevertheless, a correlation between this erosional phase and a negative sea level oscillation within the OIS 9 cannot be excluded.

TORRE IN PIETRA (LOWER BEDS)

Caloi & Palombo, 1978; Malatesta, 1978a, b; Masini *et al.*, 1991; Caloi *et al.*, 1998 and references there in.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS 9).

Large Mammal Fauna: *Vulpes vulpes*, *Canis lupus*, *Ursus spelaeus*, *Panthera (Leo) spelaea*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Cervus elaphus*, *Megaloceros giganteus*, *Bos primigenius*.

Observations: On the basis of the preliminary results of the taphonomic analysis, now in progress (Palombo, unpublished data) the mammal remains found in the lower fossiliferous level display quite different conditions of preservation. Fragments abraded and polished by prolonged transportation prevalent; in several specimens the outer bone surface is removed in several point, some other remains show longitudinal crackings or traces of weathering. This is consistent with a burial in fluvial environment.

CASTEL DI GUIDO

Caloi & Palombo, 1988; Masini *et al.*, 1991; Barbi & Sala, 1996 and references there in.

Age: Early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, ?OIS 9).

Large Mammal Fauna: *Canis* sp. (*Canis* aff. *C. mosbachensis*, Sala & Barbi, 1996), *Canis lupus*, *Panthera (Leo) spelaea*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus hundsheimensis*, *Hippopotamus* ex gr. *H. amphibius*, *Cervus elaphus*, *Bos primigenius*.

Observations: Sala & Barbi (1996) have hypothesised for this fauna a latest Galerian or earliest Postgalerian (*sensu* Sala *et al.*, 1992), considering this later more probable.

According to Caloi *et al.* (1998), the sediments outcropping in both these sections can be related to the Aurelia Formation (Conato *et al.*, 1980) because they

overlie the «*tuffo rosso a scorie nere*» or contain reworked fragments of it. Consequently, the difference in age cannot be of any important relevance from a biochronological point of view.

MALAGROTTA

Caloi & Palombo, 1980c; Cassoli *et al.*, 1982; Caloi & Palombo, 1995; Caloi *et al.*, 1998.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS 9).

Large Mammal Fauna: *Canis* cf. *C. lupus*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus ferus*, *Stephanorhinus* cf. *S. hemitoechus*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama* cf. *D. clactoniana*, *Cervus elaphus*, *Bos primigenius*.

PONTECORVO

Biddittu & Cassoli, 1968; Caloi & Palombo, 1988, 1995.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS 9).

Large Mammal Fauna: *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus ferus*, *Stephanorhinus* sp., ?*Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Cervus elaphus*, *Megaloceros giganteus*.

Observations: The correlation with the Torre in Pietra FU is made on the basis of the typology of Lower Paleolithic industry; the faunal list is consistent with this hypothesis.

RIANO

Maccagno, 1962b; Leonardi & Petronio, 1974, 1976; Masini *et al.*, 1991; Caloi *et al.*, 1998.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS 9).

Large Mammal Fauna: *Elephas* (*Palaeoloxodon*) *antiquus*, *Stephanorhinus* sp. (cf. *Stephanorhinus hemitoechus*), *Dama clactoniana*, *Cervus elaphus* (= *Cervus elaphus rianensis* Leonardi & Petronio, 1974).

Observations: According to Malatesta (1978b) the pyroclastic-diatomaceous deposits of Riano, strictly represent the continental facies equivalent to the fluvio-lacustrine-brackish-marine sediments that form the Aurelia Formation (Caloi *et al.*, 1998).

QUISISANA, CAPRI

Capasso Barbato & Gliozzi, 1995 and references there in.

Age: early Aurelian (Torre in Pietra FU) (late Middle Pleistocene, OIS 9).

Large Mammal Fauna: *Canis* sp. ex gr. *C. mosbachensis*, *Ursus spelaeus*, *Crocota crocuta*, *Panthera pardus*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Mammuthus* ex gr. *M. chosaricus*-*M. primigenius*, *Equus* aff. *E. suessenbornensis*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Sus scrofa*, *Cervus elaphus*, *Dama* sp., *Bos primigenius*.

Observations: The age of the fauna is based on the taxonomical composition and on the presence of Lower Paleolithic industry, comparable to those found in the lower levels of the Torre in Pietra sequence (Capasso Barbato & Gliozzi, 1995). The occurrence of a equid related to *Equus* aff. *E. suessenbornensis* does not agree with the probable age of the fauna and have to be confirmed.

BUCINE

Masini *et al.*, 1991; Ferretti, 1997; Gliozzi *et al.*, 1997; Mazza, 1997 and references there in.

Age: ?early/middle Aurelian (? Torre in Pietra/Vitinia FU) (late Middle Pleistocene).

Large Mammal Fauna: *Canis lupus*, *Ursus arctos*, *Crocota crocuta*, *Mammuthus* (*Mammuthus*) ex gr. *M. chosaricus*-*M. primigenius*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus suessenbornensis*, *Stephanorhinus* sp., *Sus scrofa*, *Capreolus capreolus*, *Dama dama*, *Cervus elaphus*, *Megaloceros* sp. (? *M. giganteus*), ? *Bos primigenius*, ? *Bison priscus*.

Observations: The Bucine mammal collection was assembled over a long period of time, since the 40's. The fossil mammal remains come from late Middle Pleistocene fluvial sands and gravels outcropping at several localities distributed along the valley of Ambra torrent, a left-hand tributary of the Arno river. The results of the taphonomic analysis «suggest that the deposit probably formed mostly by attritional processes and was slightly reworked from the original site of accumulation», moreover the fauna lived under severe climatic conditions (Mazza, 1997).

This composed fauna was attributed to Vitinia FU by Gliozzi *et al.* (1997), but the occurrence of *Equus suessenbornensis* should be consistent with an older age (?Torre in Pietra FU), moreover this opposes the presence of *Dama dama*.

CONTRADA MONTICELLI

Mazza & Varola, 1999 and references there in.

Age: Middle Pleistocene, ?Aurelian.

Large Mammal Fauna: *Canis* sp. aff. *C. mosbachensis*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus hundsheimensis*, *Dama dama*, *Bos* sp. (?*Bos primigenius*), *Bison* sp.

GROTTA ROMANELLI

Masini *et al.*, 1991; Mussi, 1992.

Age: ?early Aurelian (Torre in Pietra FU) (late Middle Pleistocene).

Large Mammal Fauna: *Vulpes vulpes*, *Canis* sp. aff. *C. mosbachensis*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus kichbergensis*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*.

TORRE IN PIETRA (UPPER BEDS)

Caloi & Palombo, 1978; Malatesta, 1978a, b; Di Stefano & Petronio, 1997; Caloi *et al.*, 1998 and references there in.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Macaca sylvanus sylvanus*, *Vulpes vulpes*, *Canis lupus*, *Meles meles*, *Martes foina*, *Ursus* sp., *Crocota crocuta*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The preservation of the main part of mammals fossils coming from the fluvial gravel at the bottom of the second sedimentary cycle, suggests a burial after transportation and/or exposition. The large mammal remains showing a good preservation, as well as the micromammals, probably have been found in the in silty-clay lents corresponding to phases of low energy depositional conditions (Palombo, unpublished data).

VITINIA (UPPER BEDS)

Caloi *et al.*, 1993, 1998; Di Stefano & Petronio, 1997.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Vulpes vulpes*, *Canis lupus*, *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus* sp., *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: At Vitinia-Quartaccio, the most complete Middle Pleistocene section of «Campagna Romana» is present. Here, in fact all three late-Middle Pleistocene cycles (San Cosimato, Aurelia and Vitinia Formation, Conato *et al.*, 1980) are present, overlying the eroded deposits of Ponte Galeria Formation. Scanty mammal remains have been found in the gravel belonging to Ponte Galeria Formation and from the clays and silts of the Aurelia Formation. The most important fauna, very rich in red deer remains, belonging to the gravels of the Vitinia Formation, here defined (Conato *et al.*, 1980; Caloi *et al.*, 1993, 1998).

CERVETERI

Capasso Barbato *et al.*, 1983; Caloi & Palombo, 1988, 1995; Di Stefano & Petronio, 1997; Caloi *et al.*, 1998.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus* sp., ?*Dama clactoniana*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The attribution to the Middle Aurelian bases on the presence of *Dama dama tiberina*. In fact the remains have been found in «tufi di disfacimento» level, which overlay a deep erosion surface cutting the Sabatini «Tufo rosso a scorie nere». Stratigraphical data lack to confirm if the bone bed should be correlated with the Aurelian or the Vitinia Formation.

CASAL DE' PAZZI

Anzidei *et al.*, 1984, 1999 and references there in.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: ?*Canis* sp. aff. *C. arnensis*, *Canis lupus*, *Crocota crocuta*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus* sp., *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The analysis of the fauna is in progress. According to the preliminary results the character of the fauna is consistent with an attribution to Vitinia FU.

SEDIA DEL DIAVOLO

Blanc, 1955; Caloi *et al.*, 1980, 1998; Caloi & Palombo, 1988; Di Stefano *et al.*, 1998.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Canis lupus*, *Elephas (Palaeoloxodon) antiquus*, *Equus hydruntinus*, *Equus ferus*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Dama clactoniana*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The section of Sedia del Diavolo, formerly visible within the city of Rome, is no longer exposed, but a reinterpretation is possible based on unpublished data by A.C. Blanc and by reconstruction put forward in previous studies. Three sedimentary cycles can be detected belonging to San Cosimato, Aurelia and Vitinia Formation. «Tufo litoide lionato» interbeds between the first and the second sedimentary cycles. The classic and main important faunal assemblage, here reported, have been found in gravels and sands as well as in marls of the III sedimentary cycle (Sedia del Diavolo 3 according to Di Stefano *et al.*, 1998).

MONTE DELLE GIOIE

Blanc *et al.*, 1955; Caloi *et al.*, 1980, 1998; Caloi & Palombo, 1988.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus* cf. *S. hemitoechus*, *Hippopotamus* ex gr. *H. amphibius*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*.

Observations: The stratigraphical data confirming a correlation with the Sedia del Diavolo sequence, have been carried out by A.C. Blanc unpublished data.

PRATI FISCALI

Kotsakis & Palombo, 1979; Caloi *et al.*, 1998.

Age: ?middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Panthera pardus*, *Elephas (Palaeoloxodon) antiquus*, *Equus ferus*, *Stephanorhinus hemitoechus*, *Dama dama* cf. *D. dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The herbivores fossils have been found in gravels and sands that overlie an erosion surface cutting the epivolcanites, silts and sand with reworked fragments of «Tufo rosso a scorie nere» (Palombo, unpublished data). The fossiliferous levels can be correlated with the third depositional cycle outcropping in the area (Caloi *et al.*, 1998). It is possible, but not sure, that the leopard skull found at this site (Kotsakis & Palombo, 1979), belongs to the same sedimentary cycle.

FARA SABINA

Angelelli, 1983; Caloi & Palombo, 1988, 1995.

Age: middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Ursus* sp., *Elephas (Palaeoloxodon) antiquus*, *Equus hydruntinus*, *Equus ferus*, *Stephanorhinus* cf. *S. hemitoechus*, *Sus scrofa*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius*.

Observations: The correlation with the Vitinia FU bases on the occurrence of both *Dama dama tiberina* and *Equus hydruntinus*.

CAMPO VERDE

Mazza *et al.*, 1992; La Rosa *et al.*, 1993; Caloi & Palombo, 1995; Caloi *et al.*, 1998.

Age: ?middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS 7).

Large Mammal Fauna: *Canis* sp. aff. *C. arnensis*, *Ursus* sp., *Mammuthus (Mammuthus)* ex gr. *M. chosaricus-M. primigenius*, *Elephas (Palaeoloxodon) antiquus*, *Equus hydruntinus*, *Equus ferus*, *Stephanorhinus* cf. *S. hemitoechus*, *Stephanorhinus* cf. *S. hundsheimensis*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama dama*, *Cervus elaphus*, *Megaloceros giganteus*, *Bos primigenius*, *Caprinae* indet.

TORRENTE CONCA

Conti *et al.*, 1982; Biondi *et al.*, 1984; Nesci & Savelli, 1991; Ferretti, 1997.

Age: Aurelian (Late Pleistocene).

Large Mammal Fauna: *Ursus arctos*, *Mammuthus* (*Mammuthus*) ex gr. *M. chosaricus*-*M. primigenius*, *Equus ferus*, *Stephanorhinus* sp. (cf. *S. hemitoechus*), Cervini indet., *Bison priscus*, *Rupicapra* sp.

Observations: The elephant was referred by Ferretti (1997) to *Mammuthus* cf. *M. primigenius* or to the *M. fraasi-chosaricus* group, considered by the author as a possible transitional group to the true *M. primigenius*.

The fluvio-lacustrine sequence of the Conca river was attributed to the penultimate Glacial and to the last Glacial by Conti *et al.* (1982) and Nesci & Savelli (1991) respectively. A "pre Wurmian" age should be more probable according to Sala in Conti *et al.*, 1982.

PAGLICCI (EXTERNAL BEDS)

Bartolomei, 1980; De Giuli, 1980; Galiberti, 1984; Masini *et al.*, 1991.

Age: ?middle Aurelian (Vitinia FU) (late Middle Pleistocene, OIS ?7-6).

Large Mammal Fauna: ?*Equus ferus*, *Rupicapra* sp., *Capra ibex*, *Cervus elaphus*.

Observations: The main part of fossil mammals have been found in the clay-sandy level 3 together with lower Paleolithic industry. According to Bartolomei (1980), the micromammals assemblages could be consistent with an arid environment.

MONTIGNOSO

Rustioni *et al.*, 1999.

Age: Middle-Late Pleistocene.

Large Mammal Fauna: *Vulpes vulpes*, *Canis lupus*, *Ursus arctos*, *Crocuta crocuta*, *Lynx* sp., *Felis silvestris*, *Panthera pardus*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Equus ferus*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Hippopotamus* ex gr. *H. amphibius*, *Capreolus capreolus*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*, *Bison* sp.

Observations: The vole is represented by a form transitional between *A. cantianus* and *A. terrestris*, while the porcupine seems to be closely related to *H. vinogradovi*, which is typical of the Emian (Rustioni *et al.*, 1999). Moreover, the occurrence of *Felis silvestris* before the last glacial is not sure. So a Late Pleistocene age seems to be more appropriate.