

F. MARCOLINI (*)

CONTINENTAL LOWER VALDARNO RODENT BIOCHRONOLOGY AND TWO NEW METHODS FOR THE SYSTEMATICS OF *MIMOMYS* (*ARVICOLIDAE, RODENTIA*)

Abstract - Small mammal faunas may be very useful for biochronologic reconstructions and give palaeoclimatic and palaeoenvironmental informations. Some new sites have been studied, both on the left-hand side and on the right-hand side of the Arno River, containing small mammal remains. Biochronological relationships between continental series of the Arno right-hand side and the marine series of the left-hand side have been proposed.

Two new morphometric methods have been tested on some populations of *Mimomys*, in order to help the systematics of this genus.

Key words - Plio-Pleistocene, Biochronology, Lower Valdarno, Morphometry, Small mammals.

Riassunto - *Biocronologia a roditori del Valdarno inferiore continentale e due nuovi metodi per la sistematica di Mimomys (Arvicolidae, Rodentia)*. I micromammiferi sono da anni utilizzati con successo per ricostruzioni biocronologiche fornendo inoltre numerose informazioni paleoclimatiche e paleoambientali. Sono stati studiati alcuni nuovi giacimenti a micromammiferi, sia in destra che in sinistra orografica dell'Arno. Sono state proposte alcune correlazioni biocronologiche tra i depositi continentali affioranti in destra orografica dell'Arno e quelli marini prevalenti in sinistra. Sono stati applicati due nuovi metodi morfometrici ad alcune popolazioni di *Mimomys* (Arvicolidae, Rodentia, Mammalia) allo scopo di migliorare le conoscenze sistematiche di questo genere molto spesso utilizzato in chiave biocronologica.

Parole chiave - Plio-Pleistocene, Biocronologia, Valdarno inferiore, Morfometria, Micromammiferi.

INTRODUCTION

In order to reconstruct the biochronological frame and the stratigraphical relationships among continental series of the right-hand side of the Arno river and to correlate them with the marine series of the left-hand side the analysis of small mammal faunas may be very useful, giving biochronologic, palaeoclimatic and palaeoenvironmental informations.

Several outcrops have been test sampled, both on the left-hand side and on the right-hand side of the Arno river, searching for deposits containing small mammal remains.

The sites of Cava Campani (PI), Vinci (FI) and Casa Sgherri (PI) were bearing material good enough to be

studied. Moreover, two new kind of morphometric analyses have been applied to the masticatory surface of first lower molars of some species of the arvicolid genus *Mimomys* (Rodentia, Mammalia). The great biochronologic importance of this genus and the apparent confusion between the numerous species belonging to it, suggested to try a new objective approach to its study. Statistical analyses have been performed on several populations from different Late Pliocene to Early Pleistocene European sites in order to test these new methods. Lately they have been applied to Italian assemblages and to Casa Sgherri assemblage.

GEOLOGICAL SETTING

In Lower Valdarno area sediments spanning from Lower Pliocene to Upper Pleistocene-Holocene outcrop (Fig. 1). The marine Pliocene cycle deposits are represented by the «Argille Azzurre» Fm, followed by the Sabbie Gialle Fm, traditionally representing a shallow water marine environment (Marroni *et al.*, 1990), testifying the beginning of the regressive cycle. The uppermost strata of the Argille Azzurre are attributed to the Middle Pliocene (Bossio *et al.*, 1981; Marroni *et al.*, 1990) as well as the Sabbie Gialle. A regional uplift corresponds to the end of this cycle, Middle Pliocene in age, as documented in the basins of the Arno left-hand side (Bossio *et al.*, 1981; Bossio *et al.*, 1993). From this moment on the depositional environments developing on the different sides of the Arno river are definitely different. On the left-hand side the transgressive overlying sediments of the “Sabbie e Argille ad *Arctica islandica*” Fm are discordant over the Sabbie Gialle and represent the Early Pleistocene marine ingressions. According to Mazzanti (1983), Nencini (1984), Lazzarotto *et al.* (1990), Marroni *et al.* (1990) the sedimentation gap between this new cycle and the underlying Pliocene deposits starts during Middle Pliocene, continues on during Late Pliocene and partly during the Santerian, marking the beginning of Early Pleistocene (Bossio *et al.*, 1993). Another interpretation, suggested by Zanchetta *et al.* (1995), Zanchetta and Mazza (1996) and Marcolini *et al.* (2000), is confirmed by the recent study of Casa Sgherri mammal fauna and of the findings at Vinci (Marcolini, 2001) and will be illustrated and discussed later.

(*) Dottorato di Ricerca in Scienze della Terra, XIII Ciclo, Università di Pisa.

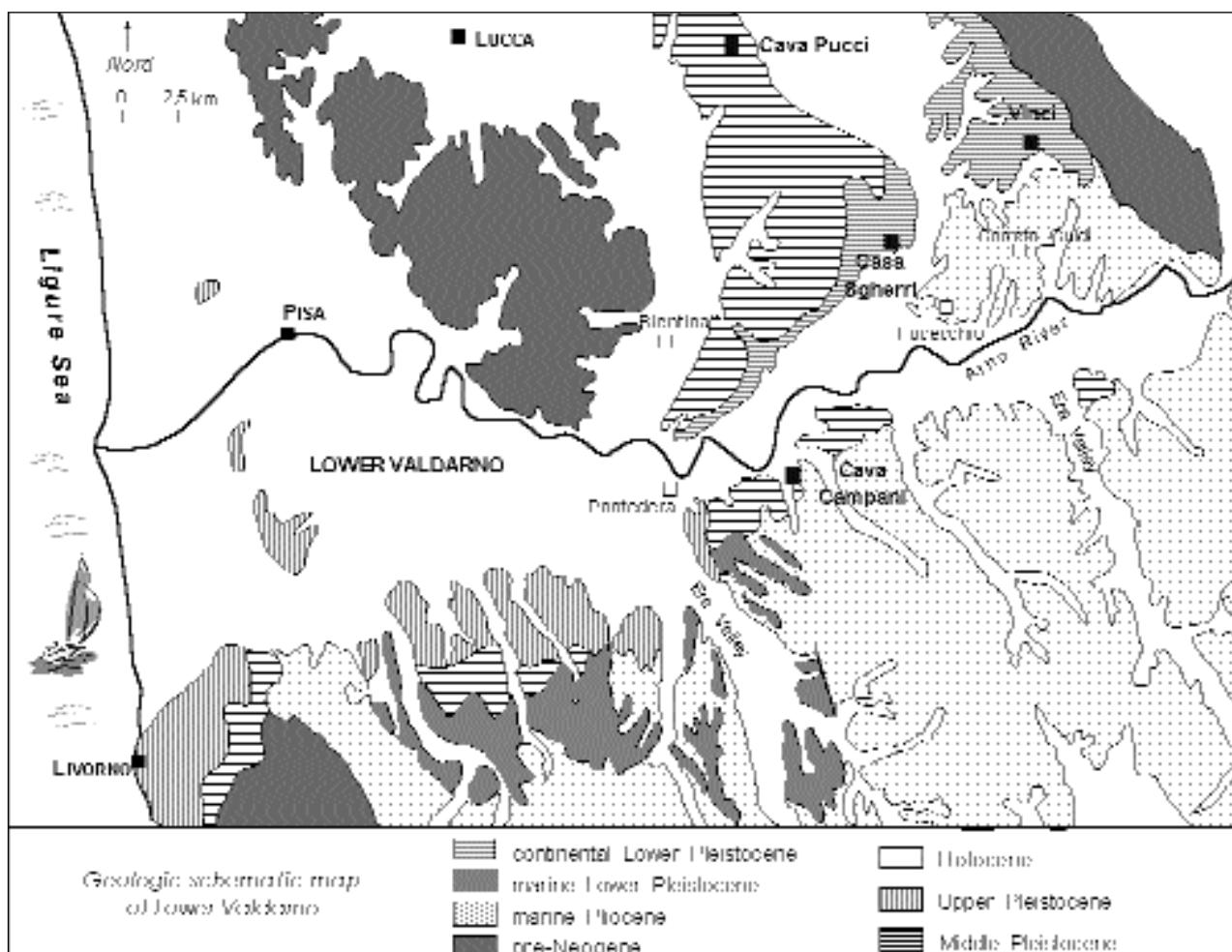


Fig. 1 - Lower Valdarno geologic sketch map.

The regressive phase is represented by the following «Sabbie di Nugola Vecchia», conformably lying over the «Sabbie Gialle», without biostratigraphically significant taxa (Nencini, 1984). The Middle Pleistocene deposits of the left-hand side, traditionally attributed to the «Conglomerati, Sabbie e Limi di Casa Poggio ai Lecci» Fm (Trevisan *et al.*, 1971; Marroni *et al.*, 1990) have been recently distinguished in two units: «Cava Ertà», basal part of Middle Pleistocene, and «San Romano», upper part of Middle Pleistocene (Zanchetta *et al.*, 1998; Tani & Gazzero, 1999). At the top of the San Romano unit lays a volcanic ash level dated several times at about 0.5 Ma (Bigazzi *et al.*, 2000 and references therein).

On the right-hand side of the Arno valley, the marine Lower-Middle Pliocene deposits are disconformably overlain by mostly continental units (Caredio *et al.*, 1995; Zanchetta *et al.*, 1995; Marcolini *et al.*, 2000). The base of the continental units accumulated during Pliocene, while the upper part is thought to pass later-

ally to the Lower Pleistocene marine deposits cropping out on the Colline Pisane (Zanchetta, 1995) bearing northern guests. On the west they are represented by the «1° ciclo lacustre» sediments (Trevisan *et al.*, 1971) and by the «Sabbie di Massarella» unit, bearing the Casa Sgherri mammal fauna. On the eastern border of the basin, along the SW border of Monte Albano, during Early and Middle Pliocene a proximal and a distal succession can be distinguished (Caredio *et al.*, 1995): «Sabbie e Conglomerati di S. Ansano» and «Argille e Sabbie di Cerreto Guidi», both correlated with an undifferentiated Early and Middle Pliocene (Caredio *et al.*, 1995). The deposits following the Pliocene sea retreat are mainly constituted by two heteropic units (Caredio *et al.*, 1995; Zanchetta, 1995): on the east the «Conglomerati di Vinci» unit, bearing at its base remains of *Equus stenonis* cf. *E. s. vireti* and *Sus* cf. *S. strozzii*, elements of the St. Vallier - Costa S. Giacomo Faunal Units (Middle Villafranchian) (Zanchetta *et al.*, 1995); on the west lies the «Argille e Sabbie di Maestromar-

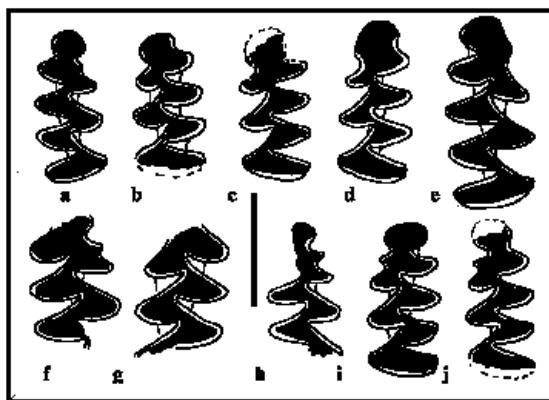


Fig. 2 - Casa Sgherri arvicolidi: a) *Mimomys pitymyoides* right M₁; b-c-h-j) *M. coelodus*, b-c and i-j left M₁, h right M₁; e-g) *M. ostramosensis*, e-f right M₁, g left M₁. Scale bar represents 2 mm. (From Marcolini, 2001).

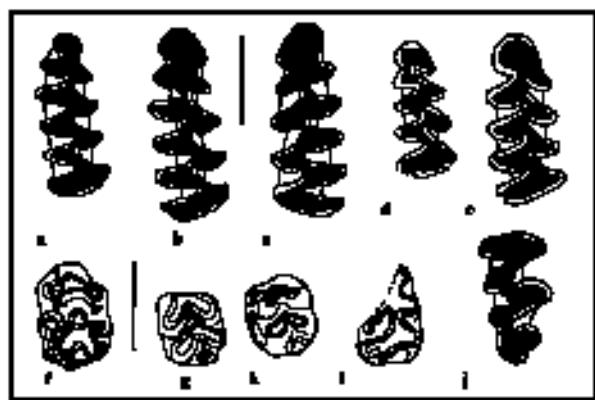


Fig. 3 - Cava Campani arvicolidi and muridi. a) *Microtus (Terricola) gr. savii*, right M₁; b-c) *Microtus (Terricola) aff. M. (T.) thomasi*, b right M₁, c left M₁; d-e) *Clethrionomys cf. C. glareolus*, left M₁; f-i) *Apodemus cf. A. sylvaticus*, f right M₁, g-h left M₂, i left M₁; j) *Arvicola cf. A. cantianus*, right M³. Scale bar represents 2 mm. (From Marcolini, 2001)

co» unit, a fluvio-lacustrine deposit correlated with late Late Pliocene or the very beginning of Early Pleistocene (Caredio *et al.*, 1995). Fluvial terraced and tilted deposits lie over these deposits: on the west «Ciotoli di Montecarlo», Early Pleistocene, and «Conglomerati delle Cerbaie» unit (Trevisan *et al.*, 1971; Puccinelli, 1991), correlated with the «Casa Poggio ai Lecci» Fm of the left-hand side of the Arno (Zanchetta, 1995). On the east the «Breccia di Casa Vetralla» is discordant over the «Conglomerati di Vinci», and is correlated with the Cerbaie sediments (Caredio *et al.*, 1995).

MATERIALS AND METHODS

The sites

At Vinci, in the surroundings of Fucecchio, in the «Conglomerati di Vinci», correlated to the post-Pliocene marine cycle of the left-hand side, *Germanomys* sp. (Arvicolidae, Rodentia) is present. *Germanomys* is known from several Late Ruscinian and Villanyian localities, such as Ivanovce, Weze (MN15b), Gundersheim, Hambach, Hajnacka (MN16a), Osztramos 7 and Rebielice (MN16b) (Fejfar, 2001). In Italy *Germanomys* is known only from the Early Villafranchian site of Arondelli. Together with *Germanomys*, an M³ attributed to *Equus gr. stenonis-senezensis* has been found.

A few km westward in the sediments of the Massarella unit, the Casa Sgherri local fauna has been found (Marcolini *et al.*, 2000). The sandy sediments of the Massarella unit have a fluvial origin, they have been interpreted as a flood plain and filled-channel deposits that locally bear mammal fossil remains (see: Zanchetta *et al.*, 1995). The Casa Sgherri level represents one of the channel fillings, bearing both large and small mammals: *Macaca sylvana florentina*, *Enhydrichtis ardea*, *Acinonyx pardinensis*, *Sus strozzii*, *Pseudodama* sp., *Capreolus* sp., *Leptobos* sp. Small mammals (Fig.

2) include: *Glis* sp., *Castor* sp., *Mimomys pitymyoides*, *Mimomys coelodus*, *Mimomys ostramosensis*, *Apodemus dominans*, *Hystrix refossa* and *Oryctolagus* cf. *O. lacosti*. Even if a very important contribution to palaeoenvironmental and biochronological considerations on Casa Sgherri is given by large mammals, further biochronological indications necessarily come by the integration with information given by small mammals.

Unfortunately on the Arno left-hand side only Cava Campani assemblage has been detected. It is a fossiliferous paleosol laying on top of a continental Middle Pleistocene succession belonging to the San Romano unit (see: Zanchetta *et al.*, 1998; Marcolini *et al.*, 2001; Marcolini *et al.*, 2003). Its importance is due to the ash level laying on top of the paleosol in stratigraphical continuity with it. It has been repeatedly dated at 0.46 ± 0.04 Ma (Fission Tracks on apatites; Bigazzi *et al.*, 2000). Though Cava Campani small mammal remains are badly preserved and not very abundant, as often happens in paleosols, there is indeed the possibility to attribute a geochronologic age to the fauna (Fig. 3), that is composed by: *Rana* sp., Anura indet., *Colubrinae* indet., *Natrix* sp., Serpentes indet. (Delfino M., pers. com.) *Crocidura* sp., *Muscardinus avellanarius*, *Clethrionomys cf. C. glareolus*, *Arvicola cf. A. cantianus*, *Microtus (Terricola) gr. savii*, *Microtus (Terricola) aff. T. thomasi*, *Apodemus cf. A. sylvaticus*.

Morphometric analyses

The genus *Mimomys*, present with different species at Casa Sgherri, is considered since many years a good biochronological indicator, but the apparent confusion between the numerous species makes it sometimes difficult to obtain specific attribution when in presence of single specimens and without a population, as in the case of Casa Sgherri assemblage. That is why two new morphometric methods (simple measurements and Complex Discrete Fourier Transform) have been

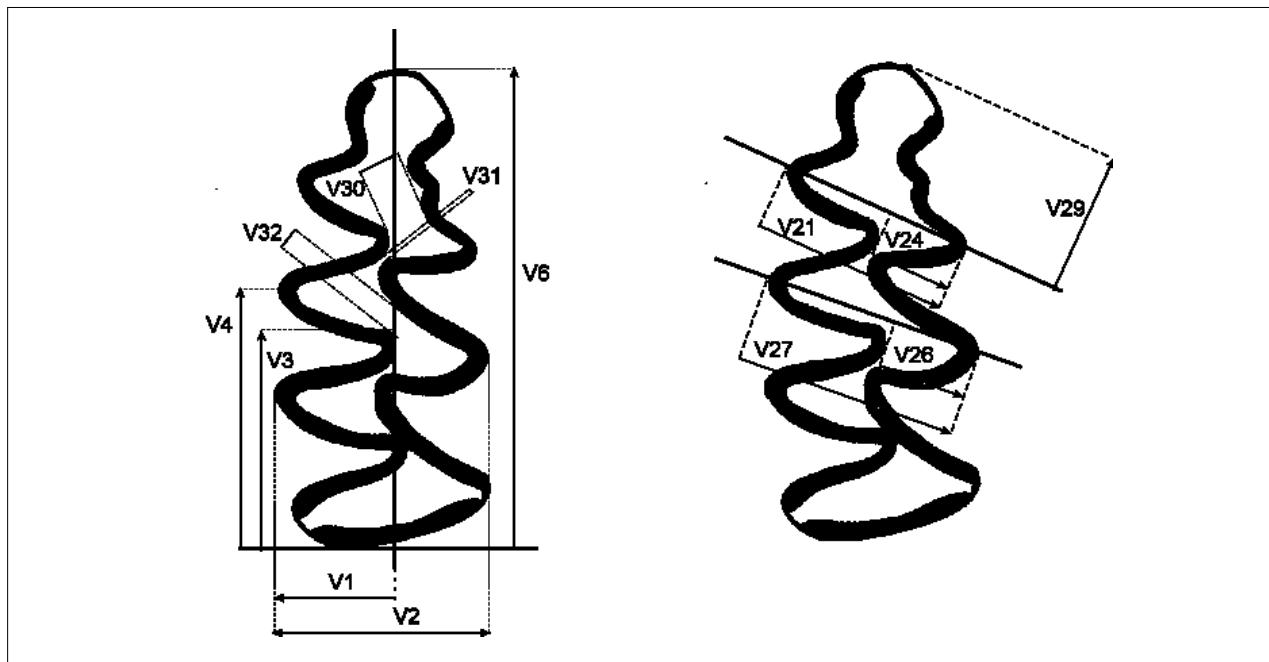


Fig. 4 - Main measurements taken on the occlusal surface of *Mimomys* M_1 .

applied to the occlusal surface of *Mimomys* M_1 of hundreds of specimens belonging to different central and western European collections, in order to test their reliability and functionality. The first one modifies Brunet-Lecomte (1988) method, that has been applied by the author to extant and fossil populations of subterranean voles of the subgenus *Microtus* (*Terricola*): 13 linear measurements and 6 indeces have been taken on the occlusal surface of M_1 (Fig. 4). This "classic" method and others used in the past, though, allow only a partial characterization of the occlusal surface morphology. That is why Dommergues (2000) developed a method called CDFT, that decomposes the tooth contour in harmonics of a Fourier series. Such an attempt was already positively resolved by Renaud *et al.* (1996) to murids. Anyway, until a very few years ago it was possible to apply it only to holomorph shapes, such as those of murid molars. Elliptic Fourier methods have been lately developed in order to characterize non-holomorph shapes: they represented a complex mathematic tool hard to be interpreted, though, until CDFT. Several statistical analyses have been applied to the results of both methods (measurements and harmonics), either Principal Component Analyses and Discriminant Analyses, obtaining good definitions of species morphological fields.

After this first step dealing with the reconstruction of species morphological fields, the variable method have been applied to Casa Sgherri big size specimen CS1, in order to have a reliable specific attribution. Results are plotted in Fig. 5a, where specimen CS1 has been analyzed by PCA with the species present at Montoussé 5 (France): *M. ostramosensis*, *M. pityomyoides* and *M.*

tornensis, falling clearly in the field of *M. ostramosensis*, indeed the species with similar size. Moreover CS1 and Montagnola Senese specimen MS64 (identified by Fondi, 1972 as *Mimomys savini*) have been analyzed with two comparable size species: *M. ostramosensis* from the type population of Osztramos 3 (Hungary) and from Montoussé 5 and *M. medasensis* from the type population of Medas Islands (Spain). Both the specimens fit in the field of *M. ostramosensis* (Fig. 5b). As to CDFT, I performed some DAs on small size species to test the reliability of the method and then it has been applied to some Italian populations. In Fig. 6a it is showed how the Italian populations of *M. tornensis*, from Monte La Mesa and Rivoli Veronese, are perfectly fitting in the Montoussé 5 and Osztramos 3 type population field. On the contrary, the same analysis performed on the Italian populations of *M. pusillus* from Pietrafitta and Monte La Mesa are separated from the group composed by the type population of Püspökfürdő (Hungary) and the population of Deutsch-Altenburg (Austria), indeed well grouped together (Fig. 6b).

DISCUSSION AND CONCLUSIONS

The finding of *Germanomys* sp. seems to relate Vinci deposit with a generic Middle to Late Pliocene. The contemporary presence of the horse molar, even if without a specific attribution, reduces the time span to Late Pliocene (Costa San Giacomo F.U.), since either *Equus stenonis* and *E. senezensis* are widespread in Europe in sites correlated with Late Pliocene and earliest Pleistocene (Alberdi *et al.*, 1998).

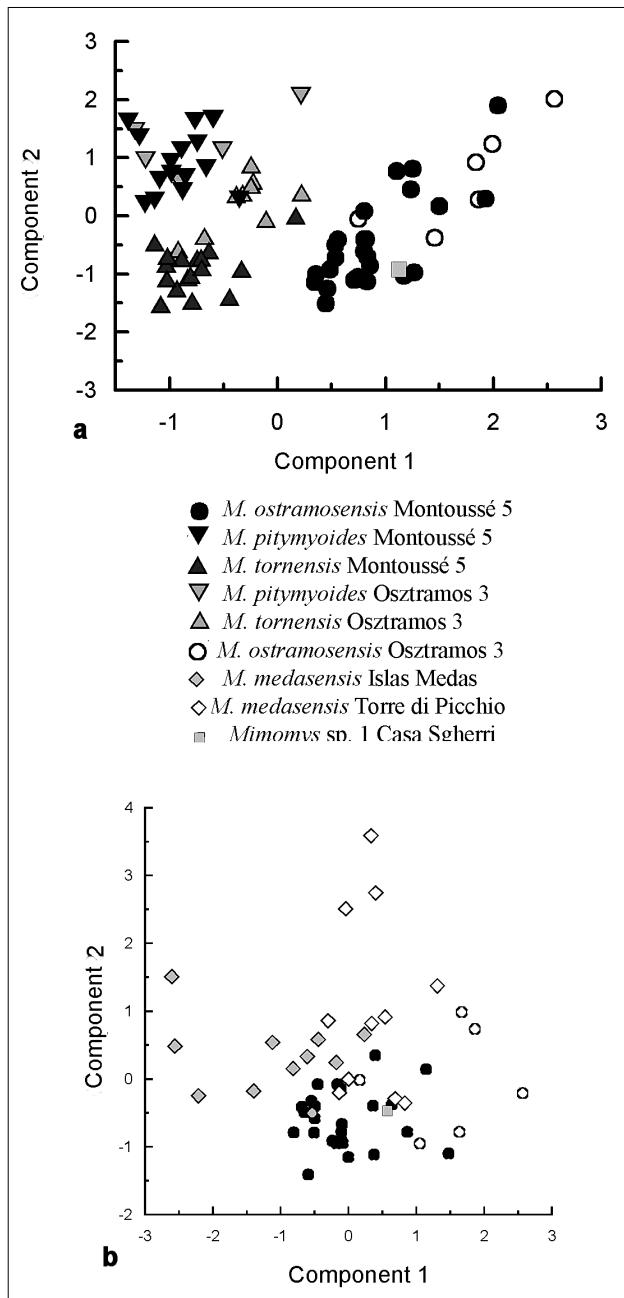


Fig. 5 - a PCA (N= 79) on Osztramos 3 and Montoussé 5 and CS1 specimens (black cross); b PCA (N=55) on *M. ostramosensis* (From: Marcolini, 2001).

As to Casa Sgherri, large and small mammal assemblage seems to be related to the Late Pliocene. The contemporary presence of *Enhydrichtis ardea*, *Acinonyx pardinensis*, *Sus strozzii* and *Macaca sylvana florentina* has important biochronological meanings since such an assemblage indicate a time lapse comprised between the Costa S. Giacomo F.U. and the Olivola F.U. As to small mammals, *Mimomys ostramosensis* Janossy &

Meulen and *Mimomys pitymyoides* Janossy & Meulen are associated in several Late Villanyian faunas and with *Macaca* sp. in Montoussé 5, assigned by the authors to a time lapse comprised between 1.7 and 2.1 Ma (see discussion in: Marcolini, 2001) while *M. coelodus* is reported from some Late Villanyian and Earliest Biharian sites of central and Eastern Europe (Akkulaevko, Pevzner et al., 2001; Deutsch-Altenburg 2c and 4b, Rabeder, 1981; Drăgănești-Olt and Izvoru, Radulescu and Samson, 1983, 2001) If we consider this piece of information, together with large mammals biochronological information the assemblage can be correlated with the Costa S. Giacomo to Olivola FUs, Late Pliocene in age.

On the basis of the fossil content, the basal portion of the Massarella unit and the Conglomerati di Vinci must be dated to the Late Pliocene, in good agreement with the recent interpretation of the Lower Valdarno area suggested by Zanchetta et al. (1995), Zanchetta and Mazza (1996) and Marcolini et al. (2000). These authors suggest that the post-Middle Pliocene cycle in the Lower Valdarno is not entirely attributable to the Early Pleistocene but it could be antedated to the Late Pliocene, as suggested by the contemporary presence of *Arcto islandica* and *Anancus arvernensis* at the beginning of the cycle (Zanchetta and Mazza, 1996; Tani and Gazzero, 1999).

The age obtained for Cava Campani, of 0.46 ± 0.04 Ma definitely gives a better insight on the chronology of Italian Pleistocene small mammals. For instance, *Microtus (Terricola)* aff. *M. (T.) thomasi* is a poorly known species, a typical Balkan element traditionally attributed to the *M. (T.) duodecimcostatus-lusitanicus* group. As a fossil it had been reported only in the Upper Pleistocene Greek site of Kalamakia (Roger and Darlas, 1999). On the basis of so scanty material it is not possible to say whether Campani quarry specimens belong to *M. (T.) thomasi* group or if we deal with a morphological convergence. This is up to day the first reported finding of a taxon morphologically similar to this group as a fossil in Middle Pleistocene sediments and outside Greece.

Microtus (Terricola) savii, to whose group belong some of Cava Campani specimens, is at present-day an endemic species of the Italian peninsula, as it was during Pleistocene (Brunet-Lecomte, 1988; Brunet-Lecomte et al., 1994). Though the Savi vole has been found in another Middle Pleistocene site, that of San Giovanni di Duino (Bartolomei, 1976; Bon et al., 1991) it has been referred to the Fontana Ranuccio F.U. only by indirect correlation (Gliozzi et al., 1997). The specimens have been not figured by the authors. Moreover Brunet-Lecomte (1988) or Brunet-Lecomte et al. (1994) didn't mention San Giovanni di Duino in their review of Italian ground voles, considering the group *savii* as starting around 0.3 Ma. The Campani quarry specimens come from a paleosol bed, where the dated level is right on top. The finding of a *M. (T.) gr. savii* in this paleosol, even if it doesn't help the systematics of its evolution, seems to antedate the inferred first appearance of this group with the direct assignment of an age.

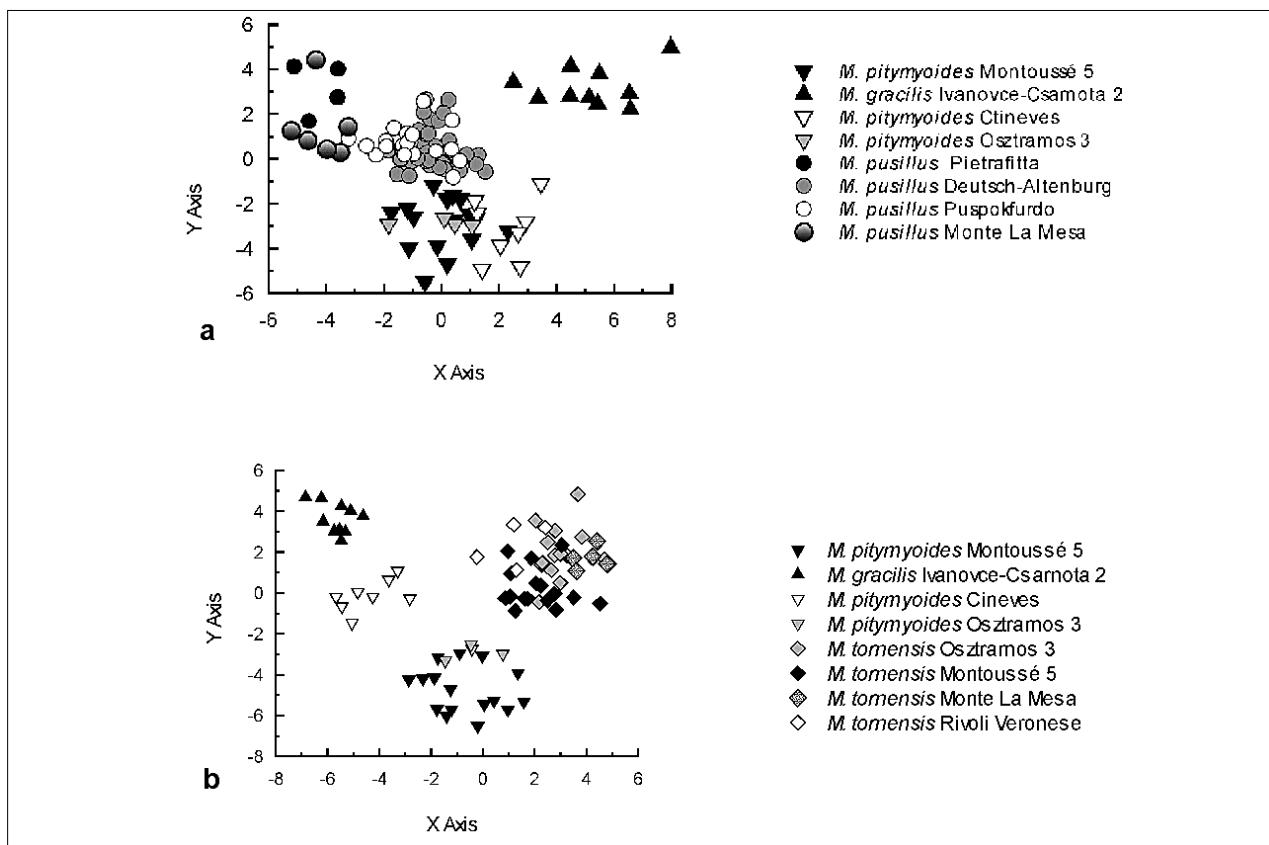


Fig. 6 - Discriminant analysis on CDFT results on three small species from different sites: a *M. gracilis*, *M. pitymyoides* and *M. tornensis*; b *M. gracilis*, *M. pitymyoides* and *M. pusillus*. (From: Marcolini, 2001).

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REFERENCES

- Alberdi M.T., Ortiz-Jaureguizar E., Prado J.L., 1998. A quantitative review of European stenonoid horses. *J. Paleont.* 72: 371-387.
- Bartolomei G., 1976. Breccia ossifera ad elefante e micromammiferi presso S. Giovanni di Duino nel Carso di Trieste. *Atti Acc. Naz. Lincei, Rend. Cl. Sci. Fis. Mat. Nat.*, serie 8, 61: 274-279.
- Bigazzi G., Zanchetta G., Bonadonna F.P., Leone G., 2000. Ulteriori dati cronologici sui depositi cineritici del Valdarno inferiore (Toscana). *Boll. Soc. Geol. It.* 119: 121-124.
- Bon M., Piccoli G., Sala B., 1991. I giacimenti quaternari di vertebrati fossili nell'Italia Nord-Orientale. *Mem. Sci. Geol.*, 43: 185-231.
- Bossio A., Costantini A., Lazzarotto A., Liotta D., Mazzanti R., Mazzei R., Salvatorini G., Sandrelli F., 1993. Rassegna delle conoscenze sulla stratigrafia del neoautoctono toscano. *Mem. Soc. Geol. It.* 49: 17-98.
- Bossio A., Mazzanti R., Mazzei R., Menesini E., Nencini C., Salvatorini G., Ughi R., 1981. Nuove osservazioni sulla stratigrafia delle formazioni plioceniche e pleistoceniche di Casciana Terme. *Atti del IX Conv. Soc. Pal. It.* 3-8: 55-90.
- Brunet-Lecomte P., 1988. Les campagnols souterrains (Terricola, Arvicolidae, Rodentia) actuels et fossiles d'Europe occidentale. *Thèse, Univ. de Bourgogne* 147.
- Brunet-Lecomte P., Sala B., Chaline J., 1994. Comparative morphology of the first lower molar of present-day and fossil populations of ground voles in Italy (Rodentia, Arvicolidae). *Il Quaternario* 7: 35-40.
- Caredio P., Esu D., Testa G., 1995. Il margine orientale del bacino plio-pleistocenico di Lucca-Montecarlo-Vinci: evoluzione stratigrafica e tettonica. *St. Geol. Camerti, Vol. Spec.* 235-253.
- Dommergues C.H., 2000. Développement d'une application Matlab d'analyse de contour par transformées de Fourier. TX 5x Travaux de laboratoire Biogéosciences - Dijon, Université de Bourgogne, 13.
- Fejfar O., 2001. The Arvicolidids from Arondelli-Triversa: a new look. *Boll. Soc. Pal. It.* 40: 185-193.
- Fondi R., 1972. Fauna Cromeriana della Montagnola senese. *Palaeont. It.* 48: 1-27.
- Gliozzi E., Abbazzi L., Ambrosetti P., Argenti P., Azzaroli A., Caloi L., Capasso Barbato L., Di Stefano G., Ficcarelli G., Kotsakis T., Masini F., Mazza P., Mezzabotta C., Palombo M.R., Petronio C., Rook L., Sala B., Sardella R., Zanalta E., Torre D., 1997. Biochronology of selected mammals, molluscs and ostracods from the Middle Pliocene to the Late Pleistocene in Italy. *Riv. It. Pal. e Strat.* 103: 369-388.
- Lazzarotto A., Mazzanti R., Nencini C., 1990. Geologia e morfologia dei comuni di Livorno e Collesalvetti. In: La scienza della Terra nei comuni di Livorno e Collesalvetti. *Quad. Mus. St. Nat.* vol. 11, suppl. 2, 1-85.
- Marcolini F., 2001. Continental Lower Valdarno rodent biochronol-

- ogy and two new methods for the systematics of *Mimomys* (Arvicolidae, Rodentia). *Ph. D. Thesis, University of Pisa*, 188 pp.
- Marcolini F., Bigazzi G., Bonadonna F.P., Centamore E., Cioni R., Zanchetta G., 2003. Tephrochronology and tephrostratigraphy of two continental faunal (small mammals and non marine molluscs) deposits from Central Italy. *J. Quat. Science* 18: 545-556.
- Marcolini F., Bonadonna F.P., Kotsakis T., Mazza P., Zanchetta G., 2000. Preliminary data on the micro- and macromammal remains from Casa Sgherri, Lower Valdarno (Tuscany, Central Italy). *Boll. Soc. Pal. It.* 39: 243-252.
- Marcolini F., Zanchetta G., Bonadonna F.P., 2001. Some preliminary data on two small mammal bearing paleosols from the Tyrrhenian and Adriatic sides of Italy. *Oryctos* 3 (Décembre 2000): 85-94.
- Marroni M., Mazzanti R., Nencini C., 1990. Geologia e morfologia delle Colline Pisane. *Quad. Mus. St. Nat. di Livorno*, Vol. 11, Suppl. 1: 1-40.
- Mazzanti R., 1983. Il punto sul Quaternario della fascia costiera e dell'arcipelago della Toscana. *Boll. Soc. Geol. It.* 102, 419-556.
- Nencini C., 1984. Il passaggio Plio-pleistocene e i sedimenti pliocenici e pleistocenici delle colline di M. Castello. *Boll. Soc. Geol. It.* 102 (1983): 391-398.
- Pevzner M., Vangengeim E., Tesakov A., 2001. Quaternary zonal subdivisions of Eastern Europe based on vole evolution. *Boll. Soc. Pal. It.* 40: 269-274.
- Puccinelli A., 1991. Nuovi aspetti dell'evoluzione paleogeografica e tectonica al Pio-Quaternario della Piana di Lucca (Toscana). *Geogr. Fis. Din. Quat.* 14: 171-177.
- Rabeder G., 1981. Die Arvicoliden (Rodentia, Mammalia) aus dem Pliozän und dem älteren Pleistozän von Niederösterreich. *Beitr. Paläont. Österr.* 8: 1-373.
- Radulesco C., Samson P., 1983. La lignée *Mimomys minor-coelodus* (Rodentia, Mammalia) dans le Bassin dacique. *Trav. Inst. Spél. «Émile Racovitz»* 22: 57-64.
- Radulesco C., Samson P., 2001. Biochronology and evolution of the Early Pliocene to the Early Pleistocene mammalian faunas of Romania. *Boll. Soc. Pal. It.* 40: 285-291.
- Renaud S., Michaux J., Jaeger J.-J., Auffray J.-C., 1996. Fourier analysis applied to *Stephanomys* (Rodentia, Muridae) molar: non-progressive evolutionary pattern in a gradual lineage. *Paleobiology* 22: 251-265.
- Roger T., Darlas A., 1999. Étude préliminaire des microvertébrés du Pléistocène supérieur de la Grotte de Kalamakia (Areopolis, Grèce). *Mediterranean Prehistory Online* 1: <http://www.med.abc-mac.it/issue001/articles/arkeos/roger.htm>
- Tani F., Gazzero M., 1999. Nuove osservazioni sui depositi plio-pleistocenici nel bacino del Torrente Cascina. *Boll. Soc. Geol. It.* 118: 237-241.
- Trevisan L., Brandi G.P., Dallan L., Nardi R., Raggi G., Rau A., Squarci P., Taffi L., Tongiorgi M., 1971. Note illustrative della carta geologica d'Italia - Foglio 105 Lucca. Scala 1:100 000. *Min. Ind., Comm. Art., Direz. Gen. Miniere, Serv. Geol. Naz.* 1-52.
- Zanchetta G., 1995. Nuove osservazioni sui depositi esposti sul fianco sudorientale delle colline delle Cerbaie (Valdarno inferiore, Toscana). *Il Quaternario* 8: 291-304.
- Zanchetta G., Bonadonna F.P., Esu D., Grassi R., Leone G., Mazza P., 1998. Stratigraphic and palaeontologic aspects of Middle Pleistocene continental deposits from Lower Valdarno (Tuscany). *Boll. Soc. Geol. It.* 117: 113-132.
- Zanchetta G., Mazza P., 1996. *Anancus arvernensis* remains from the basal portion of the *Arctica islandica* - bearing marine deposits of Lower Valdarno. *Boll. Soc. Geol. It.* 115: 105-113.
- Zanchetta G., Petrucci S., Mazza P., Rustioni M., 1995. New Villafranchian finds from the Lower Valdarno. *Il Quaternario* 8: 449-456.

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