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Plio-Pleistocene biogeography of Italian mainland micromammals

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The analysis of the distribution of small mammals in the Italian mainland during the Plio-Pleistocene and their immigration in the Peninsula indicates the presence of many species of oriental European origin, a few iberoccitanic elements and some emdemic species. The Italian peninsula belongs to a western Mediterranean bioprovince. The north-eastern region of Italy is a transitional biogeographical zone between this province and the central European and Balcanic areas.

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INTRODUCTION

Many Italian fossil mammals of Plio-Pleistocene age are known and several localities of the Italian peninsula are famous among vertebrate paleontologists. However, till the Second World War the number of fossil remains of small mammals was very low. A few paleontologists (C.I. Forsyth Major, A. De Gregorio, C. Bosco, R. Fabiani & D.M.A. Bate) illustrated remains of rodents and insectivores (especially from the islands) but only large-sized 'micromammals' such as *Marmota*, *Castor*, *Hystrix* and lagomorphs, easier to discover during excavations, have been carefully studied. After the World War 2, the works of A. Pasa and G. Bartolomei illustrated for the first time the rich micromammalian Quaternary faunas of north-eastern Italy. During the last decades of the 20th century an increasing number of researchers followed the first pioneers.

Italian micromammalian assemblages are

mainly found in Pleistocene deposits. Nevertheless, Neogene remains are very important for paleobiogeographical reconstruction of Italian bioprovinces. During Late Miocene, mammalian evidences point out the presence of three different sub-provinces: the Apulia-Abruzzi, the Sardinia-Tuscany (both with strong endemic character) and the Calabrian-Sicilian subprovince (with evident African affinities; Torre *et al.* 2000). Only since the latest Miocene Italy has firm contacts with the rest of Europe, as testified by the presence of several immigrated taxa (most of them from eastern Europe, and a few elements from western Europe; Kotsakis *et al.* 1997).

Italian Pliocene micromammalian fossil assemblages are very few and very unbalanced from a geochronological point of view. Remains of Ruscinian age are almost unknown from the Italian mainland (this also applies to macromammals), whilst fossils of Villányian age (Fig. 1) are relatively few, but sufficient for a paleobiogeographical analysis. The number of Biharian fossiliferous sites bearing small mammals is quite low too and only Toringian assemblages are abundant, even if not well distributed in the Peninsula (Fig. 2).

In the present paper we examine micromammalian assemblages of the Italian mainland, excluding endemic assemblages from Sicily, Sardinia, smaller islands and paleoislands of the Gargano Archipelago because of their peculiar problems. Among fossil assemblages we chose to examine just the recently described or re-examined ones and chose to ignore isolated remains (if not important for paleobiogeography). Fossiliferous sites are correlated with MN unites (Mein 1990) for the Villányian, with zones of Fejfar & Heinrich (1990) and also with the Faunal Units (F.U.) succession system proposed by Azzaroli (1977) and emended by Gliozzi *et al.* (1997), a system accepted by all the Italian paleontologists working on continental Plio-Pleistocene fossil animals, both vertebrates and invertebrates. The locality list, containing faunal lists of small mammals and the bibliographical references are reported in chronological order in the Appendix. A systematic revision or a study of biochronological succession of several groups of Italian fossil micromammals is a topic of some general papers followed in this publication: Chaline (1977), Bartolomei (1980), Masini & Torre (1987), Kotsakis (1988), Bon *et al.* (1991), Brunet-Lecomte *et al.* (1994), Zanalda (1994a), Masini *et al.* (1996, 1998), Maul *et al.* (1998), Argenti (1999), Argenti & Kotsakis (1999), Fanfani (2000), Marcolini (2002). In the biochronological charts the position of some localities is aproximate and their chronological attribution is not certain.

RUSCINIAN

Only a single rodent tooth (M/1), collected in an ?early Middle Pliocene (Lina Barbera pers. comm.), brackish-marine deposit near Ariano Irpino (Campania, southern Italy) has been found. This molar has been attributed to a murid, *Centralomys* sp. (T. Kotsakis & P. Argenti unpublished data). The genus is known from the late Turolian site of Brisighella (Emilia-Romagna, northern Italy) with the type species *Centralomys benericettii* (DE GIULI) (De Giuli 1989). The age of the brackish-marine sediments of Ariano Irpino ought to correspond to the uppermost part of MN 15 unit. The more advanced faunas from the Gargano Archipelago (Apulia, southern Italy) fossil islands (where many micromammalian endemic lineages evolved) have been assigned to the latest phases of Miocene and/or to the earliest phases of Pliocene (Abbazzi *et al.* 1998). A discussion of the affinities of these endemic faunas is not a topic of the present work.

A migration from the European mainland to Sardinia near the Zanclean-Piacenzian boundary, corresponding to the uppermost part of MN 15 unit (Angelone & Kotsakis 2000, 2001), is suggested in recent works. Such a migration very probably followed an Italian-Corsican route but no fossil evidence of the ancestors of Sardinian *Prolagus* and *Rhaga-*

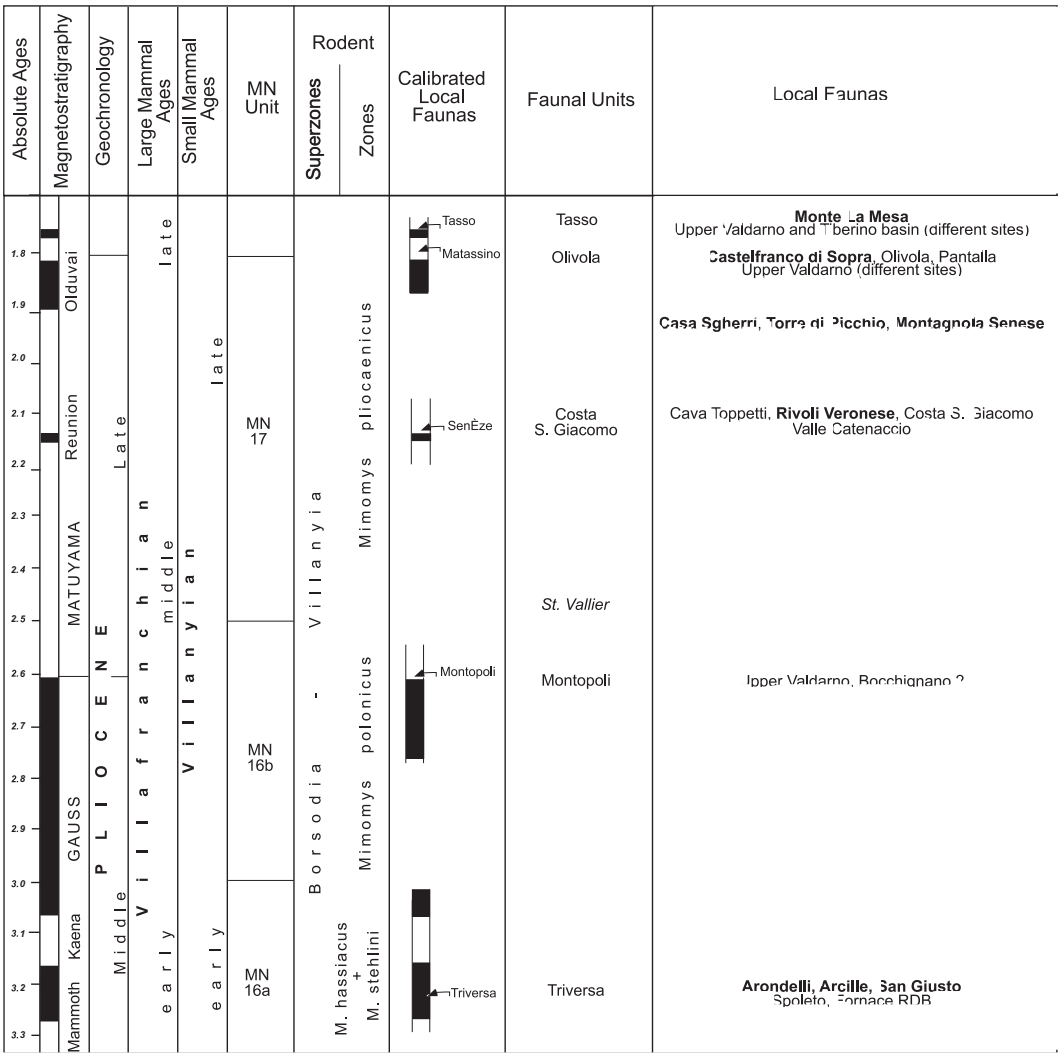

Figure 1 Biochronology of Villányian sites of Italy with micromammals. In bold character recently studied localities with relevant micromammalian remains. The chronological position of some localities is approximate.

podemus (known in southern France) has been found in Italy till now.

EARLY VILLÁNYIAN (Fig. 3)

Cascina Arondelli in the Triversa Valley (Piedmont, north-western Italy) is a famous Italian site of Early Villányian age. An assemblage of insectivores, lagomorphs and rodents has been described from this site. This fauna, assigned to MN 16a by Mein (1990) or to the *Mimomys hassiacus* (= *Mimomys hajnackensis* see Mörs *et al.* 1998) + *Mimomys stehlini* zone by Fejfar & Heinrich (1990) and Fejfar *et al.* (1998), has been collected in a sequence of mudstones, clays and fine-grained sandstones. The two rodent species collected in the fluvio-lacustrine sediments of Fornace RDB (Piedmont, north-western Italy) belong to taxa also present at Arondelli. Azzaroli (1977) formalised the Triversa F.U. as a unique fossil assemblage of small mammals (collected in Cascina

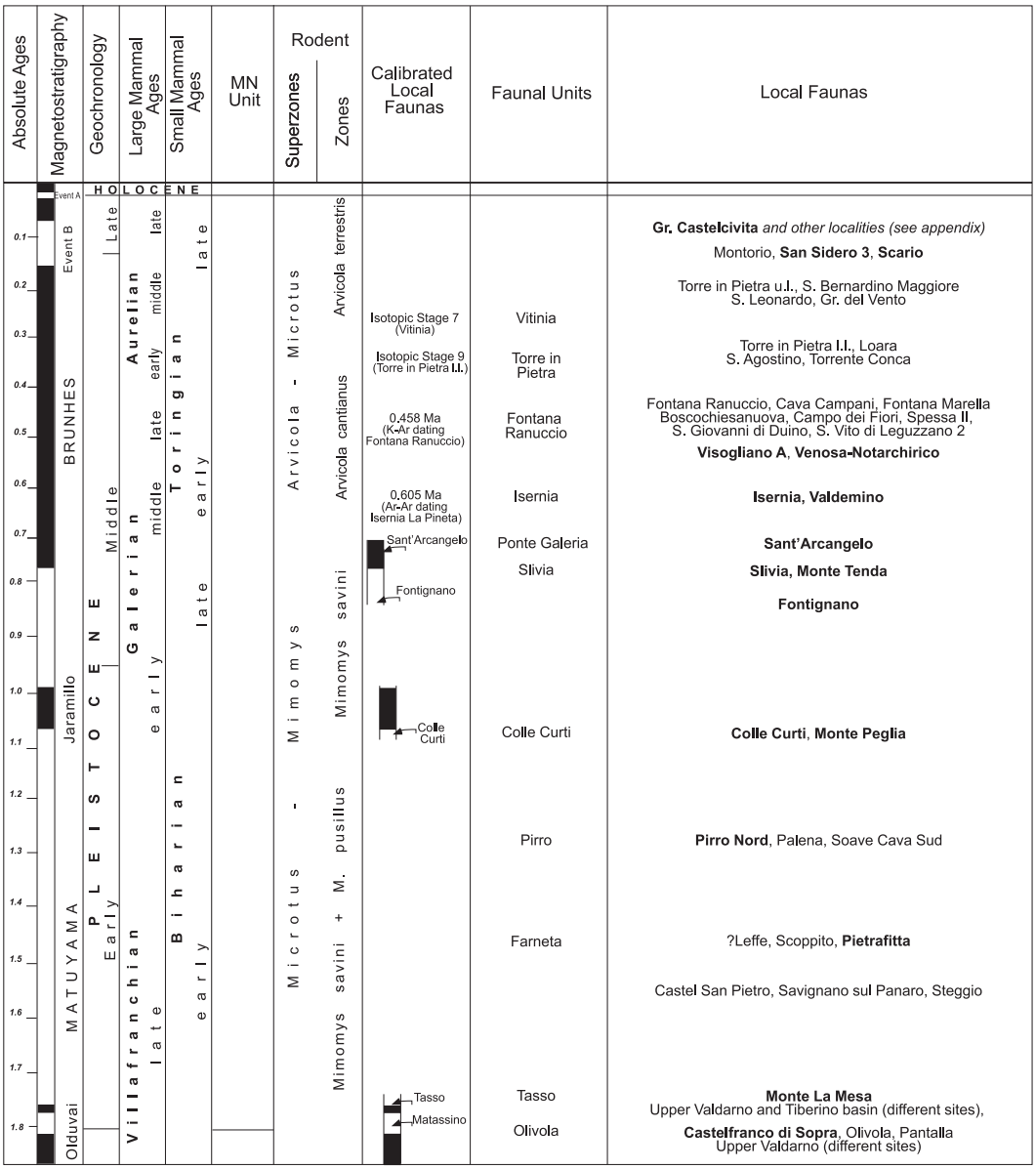

Figure 2 Biochronology of Biharian and selected Toringian sites of Italy with micromammals. In bold character recently studied localities with relevant micromammalian remains. The chronological position of some localities is approximate.

Arondelli) and large mammals (collected in Fornace RDB). After Lindsay *et al.* (1997) the age of macromammals from Fornace RDB is older than that of the micromammals from Arondelli. For this reason they assigned the large mammals of Fornace RDB (the classical Villafranchian fauna) to MN 15. For the moment there is no paleontological support to the opinion of Lindsay *et al.* (1997). Micrommamals of these assemblages belong to species of large European distribution. Similar taxa of insectivores and also rodents are present at Arcille (small sequence of clays and lignite) and San Giusto (marine-brackish

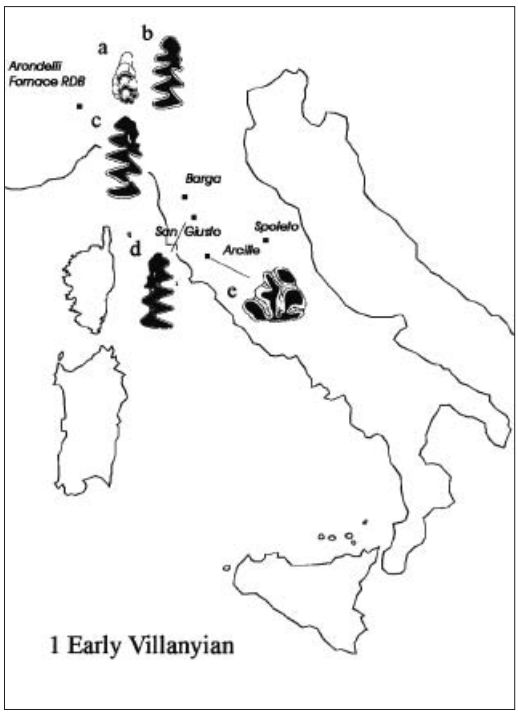

Figure 3 Distribution of micromammals in Italy during Early Villányian. Arondelli - **a**) *Apodemus alsomyoides*; **b**) *Mimomys stehlini*; **c**) *Mimomys hassiacus*. S. Giusto - **d**) *Mimomys stehlini*. Arcille - **e**) *Prolagus* sp.

Figure 4 Distribution of micromammals in Italy during Late Villányian. Rivoli Veronese - **a**) *Dinaromys allegranzii*; **b**) cf. *Ellobius* sp.; **c**) *Mimomys pitymyoides*. Montagnola Senese - **d**) *Mimomys pitymyoides*; **e**) *Apodemus mystacinus*. Torre di Picchio - **f**) *Prolagus* sp.; **g**) *Mimomys medasensis*.

sediments) (type-locality of *Mimomys* (*Cseria*) *stehlini*), both in Tuscany (central Italy). The age of the two localities is the same as Arondelli. The limited evidences support the existence of a common fauna in the western part of the Peninsula.
A large vole, probably belonging to *Mimomys polonicus* was collected many years ago in the clays of Bocchignano (Latium, central Italy). The same species of arvicolid has been discovered in Upper Valdarno (Tuscany, central Italy) (Abbazzi, unpublished data). No other discoveries of small mammals corresponding to the Montopoli F.U. have been made. Unfortunately the extremely scanty remains of micrommamals belonging to MN 16b or the *Mimomys polonicus* zone of Fejfar & Heinrich (1990) make impossible any paleobiogeographical consideration.

LATE VILLÁNYIAN (Fig. 4)

Three successive F.U.'s have been assigned to the Late Villányian (Azzaroli 1977, Gliozzi *et al.* 1997): Saint Vallier F.U., Costa San Giacomo F.U. and Olivola F.U. Small mammals belonging to Saint Vallier F.U. have not been found in Italy yet. A rich micromammalian fauna has been collected in a karst fissure near Rivoli Veronese (Veneto, north-eastern Italy). This assemblage is Late Villányian in age, and must be assigned to MN 17, to the *Mimomys pliocaenicus* zone of Fejfar & Heinrich (1990), or to Costa San Giacomo F.U. following Gliozzi *et al.* (1997). Many insectivores or rodents have a large European distribution (many of them have been described for the first time from Polish or Hungarian sites) but two elements are of particular interest: *Dinaromys allegranzii* and cf. *Ellobius* sp. (on the systematic position of

the last species see contrasting opinions in Sala *et al.* 1994 and Tesakov 1998). The first arvicolid is the older species of the genus, living today in the Dalmatian area. Its past distribution ranged from eastern Europe (Ukraine) to northern Italy through the Balkan peninsula (Sala 1996a). The second arvicolid genus is now present from Ukraine and eastern Turkey to Pakistan and Mongolia. Its presence in Europe must be assigned after Tesakov (1998) to the latest part of the Late Pliocene. At the beginning of Middle Pleistocene it reached the Maghreb (Jaeger 1988). The presence of two oriental elements at Rivoli demonstrates affinities of north-eastern Italy with eastern Europe and Balkans during the Late Villányian. Some isolated remains of the same age (Costa San Giacomo F.U.) are known from a few sites of central Italy but they belong to taxa with very large distribution.

The last F.U. of the Villányian is Olivola F.U.; some assemblages with large mammals have been assigned to it, but small mammals are very rare. Among the sites ascribed to the same F.U. (all from Tuscany and Umbria, central Italy) should be mentioned Castelfranco di Sopra (lacustrine clays and sands; Upper Valdarno), type locality of *Mimomys pliocaenicus*.

Fossil assemblages coming from three central Italian localities, the karstic fissure of Montagnola Senese (Tuscany), the fluvial deposit of Casa Sgherri (Tuscany) and the fluvio-lacustrine clays and sands of Torre di Picchio (Umbria) have been assigned to the Late Villányian, to a more recent phase than Costa San Giacomo F.U. In the first site the soricid *Crocidura* appears in Italy for the first time. This African genus reaches Europe through the Levant-Anatolian-Balkan area (Fanfani 2000). The murid *Apodemus mystacinus*, a species of Mediterranean distribution, now living in part of the Balkan peninsula, Anatolia and Levant is also present at Montagnola Senese. The origin of this taxon has been claimed from both Iberian and Balkan peninsulas. An oriental origin is possible but for the moment the most ancient records of the species are located in Iberian and Italian peninsulas and southern France (latest Villányian). The reduction of its distribution area is very probably due to the strong Middle Pleistocene climatic changes (Argenti *et al.* 2000). An Iberian element (sensu Michaux 1982), *Mimomys medasensis*, is present at Torre di Picchio. This arvicolid is known from late Villányian sites of the Iberian peninsula (Agustí 1990). The presence of *Prolagus* sp. in two of these sites (Montagnola Senese and Torre di Picchio) is also interesting. The genus has a large European distribution during the Miocene, but during the Pliocene its distribution is more restricted; at the end of the Pliocene it is reduced to western Europe with relict populations farther east. A molossid bat of the genus *Tadarida* very close to the living species *Tadarida teniotis* is present at Montagnola Senese. This typical Mediterranean species of African origin is known in the northern board of the Mediterranean till the late Turolian (Legendre 1985).

EARLY BIHARIAN (Figs. 5, 6)

There is a good number of Early Biharian micromammalian fossiliferous sites, but very few of them yield species-rich assemblages. Usually only one or two species of small mammals are present. Four F.U.'s correspond to the Early Biharian: Tasso F.U., Farneta F.U., Pirro F.U. and Colle Curti F.U.

The oldest Biharian assemblage, belonging to *Mimomys pusillus* + *Mimomys savini* zone of Fejfar & Heinrich (1990), comes from Monte La Mesa (Veneto, north-eastern Italy). A very rich assemblage of small mammals has been collected in this karstic site (Marchetti *et al.* 2000). The greatest part of the species has a large European distribution but some of them are more common in central-eastern Europe. In this site *Microtus* (*Allophaiomys*) makes its first occurrence in Italy. This arvicolid first appeared in localities of central-eastern Europe of slightly older

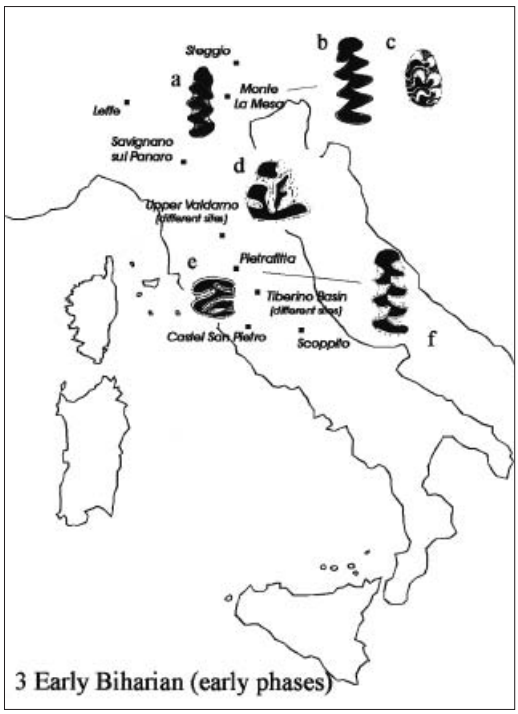

Figure 5 Distribution of micromammals in Italy during Early Biharian (early phases). Monte La Mesa - **a**) *Microtus* (*Allophaiomys*) *pliocaenicus*; **b**) *Dinaromys dalmatinus*; **c**) *Apodemus atavus*. Upper Valdarno - **d**) *Prolagus* gr. *P. michauxi* - *P. calpensis*. Pietrafitta - **e**) *Castor fiber* (not in scale); **f**) *Microtus* (*Allophaiomys*) *chalinei*.

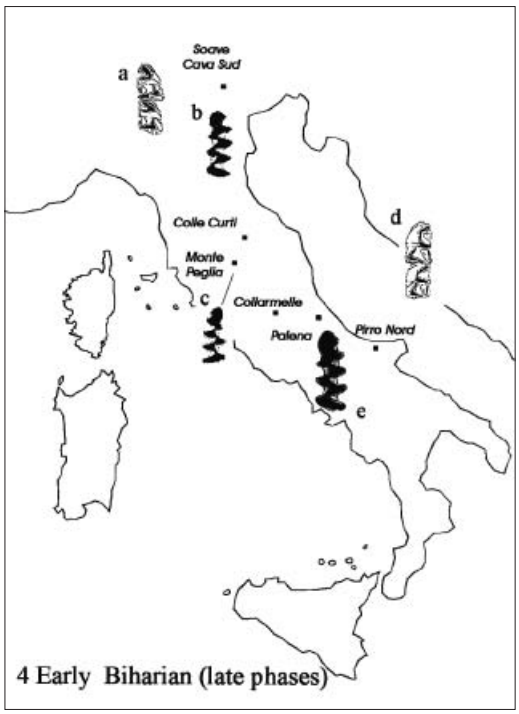

Figure 6 Distribution of micromammals in Italy during Early Biharian (late phases). Soave Cava Sud - **a**) *Crocidura zorzii*; **b**) *Microtus* (*Allophaiomys*) *ruffoi*. Monte Peglia - **c**) *Mimomys blanci*. Pirro Nord - **d**) *Asoriculus* aff. *A. theni*; **e**) *Microtus* (*Allophaiomys*) gr. *M. (A.) ruffoi*.

age (*Microtus* (*Allophaiomys*) deucalion in Villány 5, Janossy 1986). The genus *Dinaromys* is present with the species *Dinaromys dalmatinus* known from the Dalmatian area and north-eastern Italy. The murid *Apodemus atavus* is known from a few sites of central Europe and from Anatolia (Argenti 1999). All these elements indicate marked affinities between this area, the Balkans and central-oriental Europe.

Many faunas collected in central Italy (Tuscany, Umbria and Latium) are assigned to Early Biharian (Tasso F.U.) but they contain a few small mammals and all but one, rather big elements (*Castor*, *Hystrix* and lagomorphs). No elements in common with Monte La Mesa are present in these sites. This fact is probably due to ecological rather than biogeographical differences. In fact the fossils found in localities of central Italy have been collected in fluvio-lacustrine deposits whilst the assemblage of Monte La Mesa comes from a karstic fissure. Among lagomorphs the genus *Prolagus* is present for the last time in Italian mainland (cf. Rook & Masini 1990). The assemblage collected in the succession of clays and lignite of Pietrafitta (Umbria, central Italy) belongs to the Farneta F.U. Among the small mammals of this locality (Gentili *et al.* 1996) the ibero-occitanian arvicolid *Microtus* (*Allophaiomys*) *chalinei* is present. This species is also present in many sites of the same age of the Iberian peninsula (Agustí 1992). In the same assemblage *Microtus* (*Allophaiomys*) gr. *M. (A.) ruffoi* is present for the first time.

In the local fauna of Pirro Nord (typical fauna for the Pirro F.U.) and in the neighbouring local fauna of Cava dell'Erba, both collected in fissure fillings of Gargano promontory (Apulia, southern Italy), a good number of small mammals has been collected. They belong to species with large distribution. The soricid *Asoriculus* aff. *A. theni* is very similar to the typical form described on material discovered in Croatia but it is also present in some sites of western Europe (Fanfani 2000). A bat of the family Rhinolophidae, *Rhinolophus birzebuggensis*, known only from the older deposits of Ghar Dalam cave at Malta is also present. The small fauna collected in a breccia near Palena (Abruzzi, central Italy) (Kotsakis, unpublished data) is very similar to that of Pirro Nord. A third assemblage of the same age, also collected in a site of karstic origin, is that of Cava Sud (Veneto, north-eastern Italy). *Microtus* (*Allophaiomys*) *ruffoi* is a common element of the three localities; the other arvicolids present in Cava Sud are absent from the southern localities. This fact reflects ecological rather than biogeographical differences. On the contrary the presence of a big species of the genus *Crocidura*, *C. zorzii* at Cava Sud and its absence from Pirro Nord, where two other species of the genus are present, is of greatest importance. *C. zorzii* is present for a long time-span in north-eastern Italy but it is only occasionally found in other Italian regions (Fanfani 2000).

In the small fossil assemblage collected in the clayey beds of a lacustrine deposit at Colle Curti (Marche, central Italy) (Abbazzi *et al.* 1998) the first Italian occurence of the rhizodont arvicolid *Pliomys lenki* is reported. This assemblage is also characterized by the presence of a member of the subgenus *Microtus* (*Allophaiomys*) close to the beginning of the lineage leading to *Microtus* (*Pallasiinus*) *ratticepoides* - *M. (P.) oeconomus*. The second site assigned to the Colle Curti F.U. is the very well known karstic deposit of Monte Peglia (Umbria, central Italy). Two different faunas have been collected in this site but they are chronologically very close (Van der Meulen 1973). The most advanced species of *Microtus* (*Allophaiomys*) are known from western Europe (Chaline 1972; Agustí 1992; Laplana *et al.* 2000), but also from Russia (Markova 1990). *Mimomys blanci* is known from western European sites of older age (Agustí 1992; but the records of the species from north-western Europe have been rejected by Tesakov 1998) whilst the genus *Ungaromys* is an element of central and eastern Europe (Rabeder 1981). Another element of western affinities is *Apodemus* cf. *A. maastrichtiensis* (cf. Argenti 1999).

In the '*Helicella*' bearing clays of Fontignano (Ponte Galeria, Rome) two species of rodents have been collected. Surprisingly they belong to eastern species (*Prolagurus pannonicus*, and *Predicrostonyx* sp.) of cold 'steppic' environment not known from the sites of north-eastern Italy where the elements of oriental distribution are relatively common. Probably they testify a very short cold interval. The locality could be assigned to the upper part of the Early Biharian or to the lower part of the Late Biharian (Kotsakis *et al.* 1992; Barisone & Kotsakis 2001). *Predicrostonyx* is an arvicolid of north-eastern Asia and Alaska known also in eastern Europe (Nadachowski 1992). A similar form, *Predicrostonyx antiquitatis* is known from Les Valerots (France) (Chaline 1972).

LATE BIHARIAN (Fig. 7)

The faunas assigned to the Late Biharian, corresponding to the *Mimomys savini* - *Neodon gregaloides* zone of Fejfar & Heinrich (1990) or to the Slivia F.U., are very few. In Slivia (Venezia Giulia, north-eastern Italy), in a fossiliferous breccia, both the characteristic species of the zone are present, as the Balkan element *Dinaromys* sp. Gliozzi *et al.* (1997) assigned the Monte Tenda (Veneto, north-eastern Italy) assemblage, collected in a karstic deposit, to the same time interval. The first member of the subgenus *Microtus* (*Microtus*) appears in this site. Other assemblages collected in fissure-fil-

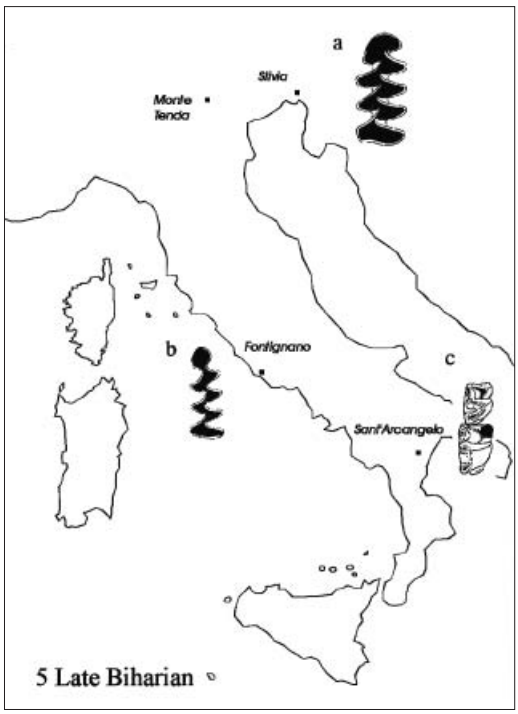

Figure 7 Distribution of micromammals in Italy during Late Biharian. Slivia - **a**) *Dinaromys* sp. *Fontignano* - **b**) *Prolagurus pannonicus*. Sant'Arcangelo - **c**) *Macroneomys brachygnathus*.

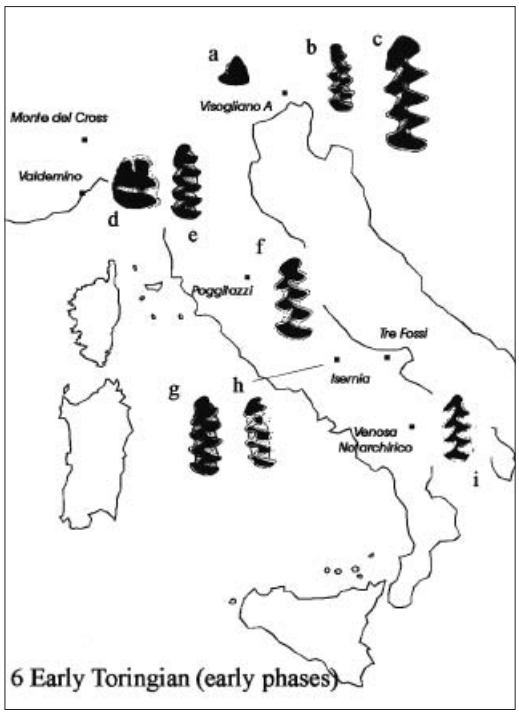

Figure 8 Distribution of micromammals in Italy during Early Toringian (early phases). Visogliano - **a**) *Ochotona* sp.; **b**) *Microtus* (*Stenocranius*) *gregalis*; **c**) *Dinaromys bogdanovi*. Valdemino - **d**) *Oryctolagus burgi* (1/2 scale dimension); **e**) *Microtus* (*Iberomys*) *brecciensis*. Isernia - **f**) *Arvicola cantianus*; **g**) *Microtus arvalinus*; **h**) *Microtus* (*Iberomys*) *brecciensis*. Poggitazzi - **f**) *Arvicola cantianus*. Venosa-Notarchirico - **i**) *Chionomys nivalis*.

lings in the Soave region, Cengelle and Viatelle (Veneto, north-eastern Italy) and illustrated by Pasa (1947) and Bartolomei (1980) very probably belong to the same age, but these faunas are not homogeneous and include elements of different age.

The fauna collected in the clays and sands of Sant'Arcangelo (Lucania, southern Italy) must be assigned to the same period but to a slightly later stage. Perhaps this fauna corresponds to Ponte Galeria F.U., a new F.U. introduced by Petronio & Sardella (1999) between Slivia F.U. and Isernia F.U. In the Sant'Arcangelo assemblage a primitive member of the genus *Terricola*, *Terricola* cf. *T. arvalidens* is present. Another very remarkable element is *Microtus* (*Iberomys*) cf. *M. (I.) brecciensis*, of Iberian origin. This is the third appearance of an Iberoccitan rodent in Italy since the beginning of the Pliocene. The subgenus made its first appearance in the Iberian Peninsula a short time before (Cuenca Bescos *et al.* 1999). In this site the soricid *Macroneomys* and *Talpa* cf. *T. romana*, a talpid very similar to the living endemic Italian species, appear for the first time (Fanfani 2000).

EARLY TORINGIAN (Figs. 8, 9)

Early Toringian faunas have been assigned to *Arvicola cantianus* zone by Heinrich & Fejfar (1990) and to Isernia F.U. and Fontana Ranuccio F.U. by Gliozzi *et al.* (1997). To the first F.U. have been assigned the assemblages collected in a paleosol in the type locality of Isernia (Molise, southern Italy) and in a cave in Borgio Verezzi (Valdemino, Liguria, north-

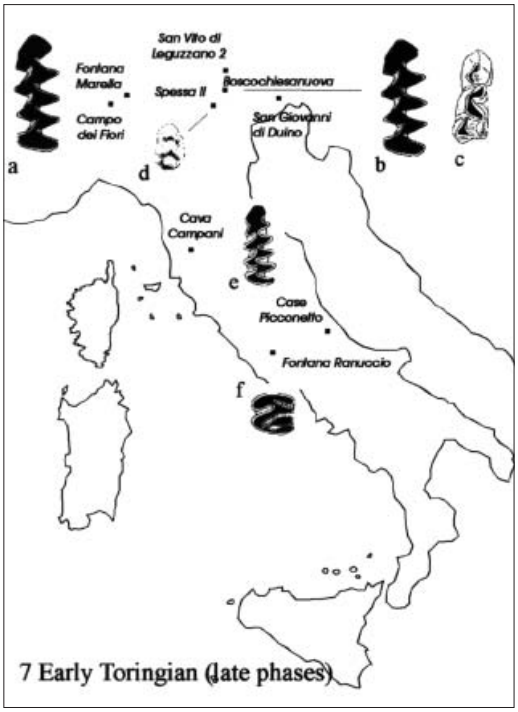

Figure 9 Distribution of micromammals in Italy during Early Toringian (late phases). Campo dei Fiori - **a**) *Dinaromys bogdanovi*. Boscochiesanuova - **b**) *Dinaromys bogdanovi*; **c**) *Macroneomys* sp. Spessa II - **d**) *Apodemus* cf. *A. microps*. Cava Campani and Case Picconetto - **e**) *Terricola* gr. *T. savii*. Fontana Ranuccio - **f**) *Castor fiber* (not in scale). Villa Castelli - **g**) *Terricola tarentina*.

western Italy). At Isernia *Arvicola cantianus* first appears in Italy. After recent radiometrical data the age of this site is younger than the one previously estimated (Coltorti *et al.* 1982, 2000). In both localities the Ibero-occitanian element *Microtus* (*Iberomys*) *brecciensis* is present. The other elements have a large European distribution except for the leporid *Oryctolagus burgi*, only known from Borgio Verezzi (Nocchi & Sala 1997a, 1997b).

The assemblages from Riparo A of Visogliano (Venezia Giulia, north-eastern Italy) belong to a more recent phase of Early Toringian, between Isernia F.U. and Fontana Ranuccio F.U. The micromammals have been collected from strata of slightly different age. In this site many 'cold' and 'cool' elements such as the ochotonid *Ochotona* sp., the sciurid *Citellus* sp., the cricetid *Cricetus cricetus* and the arvicolids *Microtus* (*Stenocranius*) *gregalis* and *Chionomys nivalis* make their first occurence in Italy. A Balkan element, *Dinaromys bogdanovi*, and the Italian endemic talpid *Talpa romana*, now living in central and southern Italy only, are also present. The 'cold' and 'cool' elements clearly arrived in the area from the east/north-east. All these species, except for *Chionomys nivalis*, lack from the assemblage of the same age collected in a fluvio-lacustrine basin at Venosa – Notarchirico (Lucania, southern Italy).

Many assemblages assigned to Fontana Ranuccio F.U. come from the same area: Boscochiesanuova (Veneto), San Giovanni di Duino (Venezia Giulia), Spessa II (Veneto) and San Vito di Leguzzano 2 (Veneto) are all karstic deposits located in north-eastern Italy. The big soricid *Macroneomys* sp. and the Balkan arvicolid *Dinaromys* are characteristic elements of these faunas. At least for this period the presence of *Dinaromys* is testified in western Lombardy (north-western Italy) in the caves of Campo dei Fiori and Fontana Marella (lower levels). At Spessa II, the presence of *Apodemus* cf. *A. microps* is worth to be mentioned. This is a living form whose distribution is limited to central Europe; fossil remains have been reported from Germany and (very probably) Hungary in coeval sites (Koenigswald 1972; Argenti 1999).

In two different sites of central Italy, Cava Campani (paleosol - Tuscany) and Case Picconetto (paleosol - Abruzzi), radiometrically related with Fontana Ranuccio F.U., a primitive form of the lineage of the endemic Italian arvicolid *Terricola savii* makes its first appearance (Marcolini 2002). This 'Mediterranean' species is also present at San Giovanni di Duino. In Cava Campani another remarkable arvicolid is present: a big *Terricola* very similar to the living *T. thomasi*, an endemic species of western Balkan area. For the moment it is impossible to decide if the remains from Tuscany belong to an ancestral form of this species or to another lineage. In this latter case the similarity

would be due to convergence phenomena.

Monte del Cros (Piedmont), another north-western Italian assemblage, is of more difficult chronological attribution. The contemporaneous presence of *Pliomys episcopalis* and *Pliomys lenki* is characteristic of some Early Toringian assemblages but a Late Biharian age can not be excluded. The paleobiogeographical interest of this site is due to the presence of a species of *Hystrix* that is smaller than the Villányian and Early Biharian *Hystrix refossa* (or *Hystrix etrusca* after other authors, see Azzaroli 1998). These remains very probably belong to the small eastern (and central) European species *Hystrix vinogradovi*.

The faunas belonging to Torre in Pietra F.U such as those of the karstic sites of Loara (Veneto, north-eastern Italy) and Sant' Agostino (Veneto, north-eastern Italy) (Gliozzi *et al.* 1997) must be assigned to a later phase of the Early Toringian. *Dinaromys bogdanovi* is present at Loara; in both assemblages the presence of *Clethrionomys* cf. *C. rufocanus* is signaled, even if a revision of the material assigned to the Sundevall's vole is necessary. Beyond north-eastern Italy only remains of species with very large distribution have been found (Torre in Pietra lower levels, Latium, central Italy).

An endemic arvicolid of the genus *Terricola*, *Terricola tarentina*, has been collected in a locality of southern Italy (Cava di Villa Castelli, Apulia) but the associated fauna is unknown. The age of this species (corresponding to the late Early Toringian) has been inferred by Brunet-Lecomte & Chaline (1991, 1992) on the ground of the supposed first appearance datum of *Terricola savii* in Italy (Brunet-Lecomte 1988).

LATE TORINGIAN (Figs. 10, 11, 12)

Late Toringian corresponds to the *Arvicola terrestris* zone of Fejfar & Heinrich (1990). In the present paper the faunas where *Arvicola* that is transitional between *A. cantianus* and *A. terrestris* is collected (e.g. Torrente Conca, Marche, central Italy, Conti *et al.* 1982) have been assigned to this age. To Vitinia F.U. belong the assemblages from the karstic deposits of Grotta Maggiore di San Bernardino (Veneto, north-eastern Italy) and Grotta di San Leonardo (Venezia Giulia, north-eastern Italy). In both faunas *Dinaromys bogdanovi* and *Marmota marmota* are present. It is the first occurrence of the alpine marmot, a sciurid of eastern origin, in Italy. An arvicolid of boreal distribution, *Microtus oeconomus* is reported from Grotta di San Leonardo. Very probably of the same age are the assemblages collected in Torrente Conca (Marche, central Italy), in Grotta del Vento (Marche, central Italy) where the boreal vespertilionid bat *Myotis dasycneme* is present, and those of Torre in Pietra upper levels (Latium, central Italy) and Grotta Paglicci (outer levels 4-3) (Apulia, southern Italy). In the latter, the Iberoccitanian element *M. (I.) brecciensis* and *Hystrix* sp. are present. Another locality where remains of *Marmota marmota* associated with a not very advanced *Arvicola* have been found is Montignoso (Tuscany, central Italy). In this assemblage an *Hystrix* dimensionally comparable with *Hystrix vinogradovi* has been found (Rustioni *et al.* 1999). Unfortunately, we cannot state with certainty that all the faunal elements have the same age, due to the fact that the fauna comes from old collections.

Assemblages dating back to last interglacial have been collected in the karstic deposits of Montorio (Veneto, north-eastern Italy), San Sidero 3 (Apulia, southern Italy) and Grotta Grande di Scario (Campania, southern Italy) among others. The survival of *Crocidura zorzii* in north-eastern and southern Italy is remarkable. The rest of the faunal elements shows a distribution similar to the present-day one, except for the presence in southern Italy of some northern-Italian elements even if in very low percentages (*Microtus* cf. *M. agrestis* at San Sidero 3 and *Terricola subterraneus* at Scario).

Many faunas date back to the last glacial. For each Isotopic Stage (4, 3 and 2) it is pos-

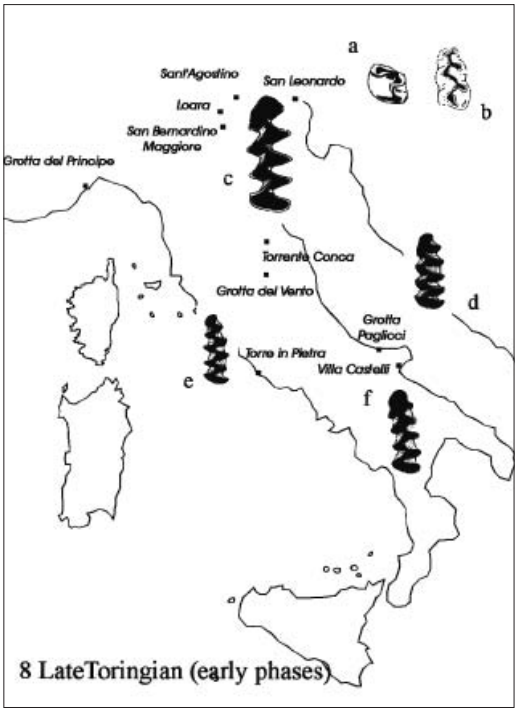

Figure 10 Distribution of micromammals in Italy during Late Toringian (early phases). Grotta S. Bernardino - **a**) *Marmota marmota* (not in scale); **b**) *Cricetus cricetus*. Several localities of Veneto - **c**) *Dinaromys bogdanovi*. Grotta Paglicci, outer levels - **d**) *Microtus (Iberomys) brecciensis*. Torre in Pietra (upper levels) - **e**) *Microtus arvalis*.

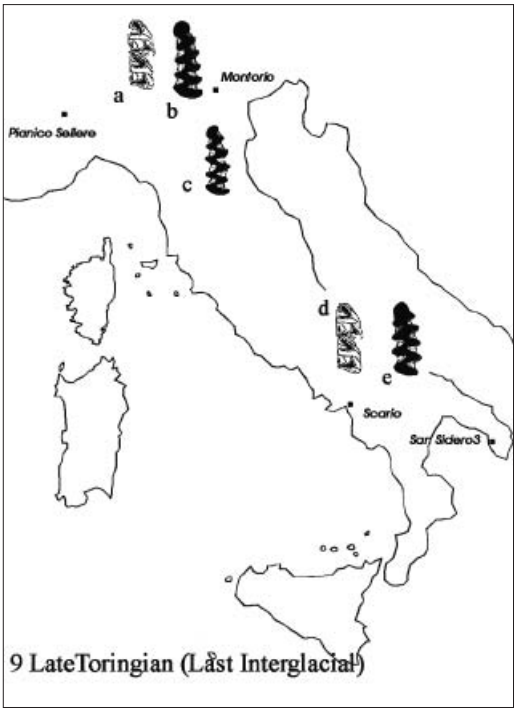

Figure 11 Distribution of micromammals in Italy during Late Toringian (last Interglacial). Montorio - **a**) *Crocidura zorzii*; **b**) *Terricola multiplex*; **c**) *Microtus* cf. *M. arvalis*. Scario - **d**) *Crocidura zorzii*; **e**) *Terricola savii*.

sible to make detailed observations about the composition of the assemblages, but our target is to provide a general framework. Thus, associations will not be ordered and divided on the basis of their age within the last glacial. The assemblages collected in the following sites have been considered: Grotta del Broion (Veneto, north-eastern Italy), Grotta A di Veja (Veneto, north-eastern Italy), Riparo Mezzena (Veneto, north-eastern Italy), Riparo della Ghiacciaia (Veneto, north-eastern Italy), Riparo Tagliente lower levels (Veneto, north-eastern Italy), Riparo Tagliente upper levels (Veneto, north-eastern Italy), Moncucco Torinese (Piedmont, north-western Italy), Grotta della Ferrovia (Marche, central Italy), Grotta Breuil (Latium, central Italy), Grotta di Sant'Agostino (Latium, central Italy), Grotta Cala (Campania, southern Italy), Grotta di Castelcivita (Campania, southern Italy), Grotta della Serratura (Campania, southern Italy), Praia a Mare (Calabria, southern Italy) and Grotta Paglicci inner levels (Apulia, southern Italy).

A general characteristic of these faunas is the appearance in north-eastern Italy of 'cold' or 'cool' elements from northern or north-eastern Europe not present in present-day Italian faunas, such as *Sicista betulina*, *Microtus (Stenocranius) gregalis*, *Microtus oeconomus*, *Ochotona pusilla*. Some of them reach central Italy in its Adriatic side (*S. betulina* and *M. oeconomus*). In the central and southern portion of the Peninsula species now living in the northern part of Italy are very common: *Marmota marmota*,

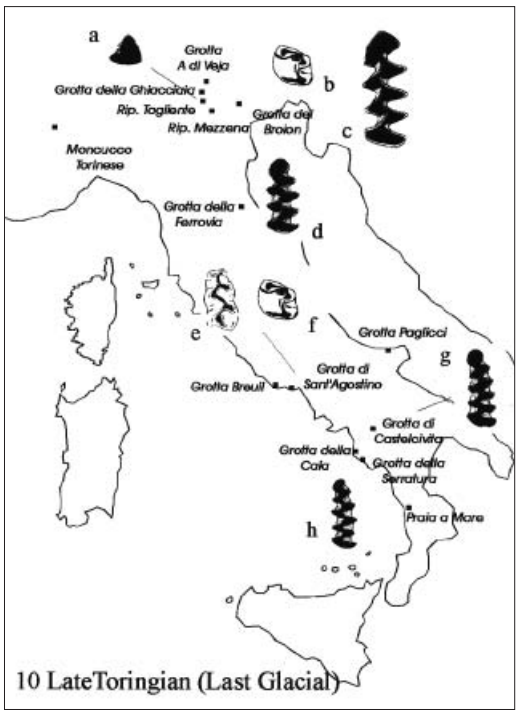

Figure 12 Distribution of micromammals in Italy during Late Toringian (last Glacial). Riparo Tagliente - **a**) *Ochotona* cf. *O. pusilla*. Several localities of Veneto - **b**) *Marmota marmota*; **c**) *Dinaromys bogdanovi*; **d**) *Microtus (Pallasiinus) oeconomus*. Grotta della Ferrovia - **d**) *Microtus (Pallasiinus) oeconomus*. Grotta Sant'Agostino - **e**) *Cricetus cricetus*; **f**) *Marmota marmota*. Castecivita - **g**) *Terricola gr. T. multiplex - T. subterraneus*. Several localities of southern Italy - **h**) *Microtus arvalis-agrestis*.

Chionomys nivalis (relict populations of this species still live in some upland zones of central Apennines), *Microtus agrestis*, *Microtus arvalis*, *Terricola* gr. *T. multiplex – T. subterraneus*, and *Cricetus cricetus* (now absent from the Italian faunas). In the southern part of the Peninsula a greater percentage of 'cold' elements on the Adriatic side is evident in comparison to the Tyrrhenian side (Capasso Barbato & Gliozzi 2001). On the contrary, 'Mediterranean' elements (*Talpa romana*, *Terricola savii*) are present in relatively small percentages during the coldest climatic oscillations in southern Italian fossiliferous sites and totally absent from northern ones; during warmer oscillations they dominate the faunal associations in southern Italy.

Repetitive variations and fluctuations of the areal distibution boundaries of the various species left some relict populations, such as the glirid *Dryomys nitedula* in Calabria, quite far from the present-day main distribution of the species (no further than north-eastern Italy). Fossil remains found in Latium (Kotsakis 1991) confirm its past wider distribution and the fact that the Calabrian population is the result of a past widening of its distribution area, and not of an anthropic deed.

More complex is the case of *Hystrix*. Its presence is signaled in a few Late Pleistocene sites both in northern and southern Italy (Anelli 1967; Broglio & Cremaschi 1992) but there is no evidence to classify them as fossils or subfossils. Till very recent times the Balkan species *Dinaromys bogdanovi* was present in north-eastern Italy. In north-western Italy a western European element *Arvicola sapidus* MILLER (Arma delle Manie, Liguria), makes its appearance, together with *Terricola multiplex* (cf. Abassi & Desclaux 1996; Abassi & Brunet-Lecomte 1997; Abassi *et al.* 1998).

HOLOCENE

Beyond *Hystrix*, introduced by man in Roman times but perhaps already present in the Peninsula (see above), during the Holocene the following species appear in Italy: *Suncus etruscus*, *Apodemus agrarius*, *Micromys minutus*, *Mus domesticus*, *Rattus rattus* and *Rattus norvegicus* (Amori 1993). *Cricetulus migratorius* not present in Italy at the present day, is signaled by Bartolomei (1982) in early Holocene sediments of Grotta degli Zingari (Venezia Giulia, north-eastern Italy). Many species of bats now living in Italy are not present in the fossil record of Plio-Pleistocene mammals of the Peninsula because studies about fossil bats are very few.

Some living terrestrial mammalian species of Italian mainland are absent from the fossil record: *Neomys anomalus*, *Terricola liechtensteini*, *Apodemus alpicola* and the endemic Italian species *Sorex samniticus*, *Sorex aurun-*

chi, *Terricola brachycercus*, *Lepus corsicanus* (Nappi 2001). Some of these species have been erected or accepted as valid taxa in recent times: thus, future revisions of fossil material collected in Italy could evidence their presence in the fossil record.

CONCLUSIONS

Our observations about the distribution of small mammals in the Italian peninsula during Plio-Pleistocene may be summarised as follows:

(**a**) During the Ruscinian only a single tooth belonging to *Centralomys* sp. has been collected in Italy.

(**b**) During the Early Villányian (Triversa F.U.) the few micromammal faunas of the Italian peninsula are composed by elements with large European distribution.

(**c**) In the Late Villányian (Costa San Giacomo F.U. and Olivola F.U.) north-eastern Italy is populated by species with a large European distribution and also by some typically eastern elements never collected more westward (*Dinaromys*, cf. *Ellobius* sp.). In central Italy an Iberian element (*Mimomys medasensis*) is present; for the first time in Italy *Crocidura*, a genus of African origin (arrived from the east through Near East - Balkans) and *Apodemus mystacinus* a typically Mediterranean murid also occur. The ochotonid *Prolagus* persists.

(**d**) In the earliest phases of the Early Biharian (Tasso F.U. and Farneta F.U.) a lot of new elements with large European distribution arrive in Italy from the north-east. The assemblages of north-eastern Italy are characterised by the presence of central-eastern European or Balkan elements like *Dinaromys* and *Apodemus atavus* whilst in central Italy another Iberoccitan element (*Microtus* (*Allophaiomys*) *chalinei*) is present.

(**e**) In the later phases of the Early Biharian (Pirro F.U. and Colle Curti F.U.) the differences between north-eastern Italy and the other parts of the Peninsula are not very marked (only the soricids of the genus *Crocidura* are different in the two areas) but our knowledge of the assemblages of north-eastern Italy is limited. Advanced members of the subgenus *Microtus* (*Allophaiomys*) are characteristic elements of this time-span. A possible Iberoccitan element (*Mimomys blanci*) is present in central Italy. An element of central-eastern European distribution (*Ungaromys*) also reaches central Italy.

(**f**) In the Late Biharian (Slivia F.U. and Ponte Galeria F.U.), north-eastern Italy is well characterised by elements as *Dinaromys* and *Neodon gregaloides* and by the first member of the subgenus *Microtus* (*Microtus*), whilst in a slightly earlier moment oriental immigrants like *Prolagurus* and *Predicrostonyx* reach central Italy. In southern Italy some characteristic 'Mediterranean' elements (*Talpa* cf. *T. romana* and *Terricola arvalidens*) and another Iberoccitan species (*Microtus (Iberomys)* cf. *M. (I.) brecciensis*) are present.

(**g**) During the early phases of the Early Toringian (Isernia F.U.) the assemblages of north-western and central Italy are characterised by the presence of *M. (I.) brecciensis* and by the appearance of *Arvicola cantianus* whilst in a slightly later moment, in north-eastern Italy we observe the arrival of many new elements of north-eastern origin (*Citellus*, *Cricetus cricetus*, *Microtus (Stenocranius) gregalis*, *Chionomys nivalis*, *Ochotona*) and the persistence of the genus *Dinaromys*. *C. nivalis* is the only species of the newcomers that penetrates during this period in southern Italy.

(**h**) In the later part of the Early Toringian (Fontana Ranuccio F.U.), north-eastern Italy is characterised by the persistence of the genus *Dinaromys*. During this timespan this arvicolid expands its range westward to north-western Italy. A central European spe-

cies, *Apodemus* cf. *A. microps* is present in an assemblage of north-eastern Italy. In central Italy we observe the first appearance of a possible ancestral form of *Terricola savii* and, a little later, its migration towards the north-east. In north-western Italy an oriental element, *Hystrix vinogradovi*, is present, but the age of this fossil is not very precise.

(**i**) The latest phase of the Early Toringian (Torre in Pietra F.U.) is characterised by the presence of *Dinaromys* in north-eastern Italy and the arrival of *Clethrionomys* cf. *C. rufocanus* from the north-east (but the systematic attribution of this last arvicolid is not certain).

(**j**) At the beginning of the Late Toringian (Vitinia F.U.) the assemblages are characterized by the presence of an *Arvicola* with S.D.Q. between A. *cantianus* and *A. terrestris*. In north-eastern Italy *Dinaromys* is always present, whilst *Marmota marmota* and *Microtus oeconomus* make their first appearance in this area. In southern Italy we observe the last occurrences of *Allocricetus bursae* and *Microtus (I.) brecciensi*s and the presence of the genus *Hystrix*.

(**k**) During the last interglacial the distribution of micromammals is very similar to the present-day situation, but *Crocidura zorzii* is present both in the north-east and in the south while in southern Italy some species now limited to the northern part of the Peninsula are present, even if with very scanty remains (*Microtus agrestis*, *Terricola subterraneus*).

(**l**) The assemblages assigned to the last Glacial are very abundant. Many 'cold' elements penetrate in north-eastern Italy (*Sicista*, *M. (S.) gregalis*, *M. oeconomus*, *Ochotona pusilla*) and some of them (*Sicista*, *M. oeconomus*) reach the Adriatic side of central Italy. *Dinaromys* is always present in north-eastern Italy. On the Tyrrhenian side of the Peninsula and in central and southern Italy many elements now absent are very abundant (*Marmota marmota*, *Cricetus*, *Microtus* (*Microtus*), *Chionomys nivalis*), whilst the 'Mediterranean' elements are always present even if in low percentages. In north-western Italy some western elements as *Arvicola sapidus* are observed during this period.

(**m**) In the assemblages of Holocene age 'cold' species disappear, whilst new elements (*Suncus*, *Micromys*, *Mus*, *Rattus*) arrive as result of human activity.

Quite a large number of micromammals have a limited range of geographical distribution; this makes them very useful for biogeographical analyses, both present-day and past ones. On the other hand, even though the big mobility of macromammals allows large-scale biochronological correlations, it does not allow a paleobiogeographical characterization at the bioprovince or sub-bioprovince level of areas with a limited geographical extension (unless we talk about islands) such as the Italian Peninsula. The only comparison we can make between large and small mammals concerns, then, the possible synchronicity of dispersal events.

The study of fossil amphibians and reptiles (in which classes we find very useful taxa for biogeographical reconstructions) does not allow observations or comparisons so far. Studies in progress, though (cf. Delfino 2002) will certainly bring very useful data. The only other group of continental animals with a considerable fossil documentation is that of non-marine molluscs. They show a particular biogeographical distribution, especially aquatic ones, for which the extension of endorheic basins and the possibilities of communication between the different hydric systems have a major importance. The non-marine mollusc faunas (especially the fresh-water ones) collected in Fornace RDB and other localities of Piedmont are characterized by a good number of endemic species and indicate strong affinities with the Rhône (France) and Rhine (Germany) valleys coeval assemblages. The

presence of assemblages dominated by endemic primitive fluvio-lacustrine prosobranchs characterize the faunas of Tuscany, Umbria and Northern Latium during the Villafranchian (corresponding to Villányian and Early Biharian) (Esu *et al.* 1993; Ciangherotti *et al.* 1998). No micromammal species, even those closely related to continental waters environments, show a similar geographical distribution.

The analytical study of macromammalian faunas evidenced several turnovers, some of which are very evident (Triversa – Montopoli, Costa San Giacomo – Olivola, Olivola – Tasso, Colle Curti – Slivia and Last Pleniglacial - Holocene) (Sardella *et al.* 1998). Other studies concerning Dispersal Events displayed at least three big events: the '*Elephas – Equus*' event, the 'Wolf' event and the 'End-Villafranchian' event (Azzaroli et. al. 1988; Torre *et al.*, 1992) in addition to the migration of single species (Torre *et al.*, 1992; Sala *et al.* 1992). The lack of data concerning micromammals does not allow comparisons between small and large mammals with regard to the first event. For the second one data are scanty too. Some changes in the composition of micromammal assemblages may be observed in north-eastern Italy comparing the faunas of Rivoli Veronese and Monte La Mesa. A major change within faunas seems to take place in coincidence with the passage between Colle Curti F.U. and Slivia F.U. It corresponds, then, to the 'End-Villafranchian' event *sensu lato*, whose existence has been doubted by Agustí & Moyá-Solá (1998). Anyway, an even more marked event seems to take place within micromammals, at least in north-eastern Italy, in Visogliano, comprised between Slivia F.U. and Isernia F.U.

In general, there does not seem to be a coincidence between large mammal and small mammal dispersal events. Moreover, the appearance of many small mammals in Italy seems to be the result of single species migration (cf. Koenigswald 1992) and not whole faunas dispersal events. Some 'cold' or 'cool' species modify their distribution area with long-timespan fluctuations due to climatic (and consequently environmental) changes; for this reason they appear more than once in north-eastern Italy, while other species living in the same area at the present day, during those time spans expand their geographical range toward the south. On the contrary 'Mediterranean' elements during warmer periods expand their distribution area towards the north, even if in a less marked way.

Kowalski (1992) distinguished the presence of a Western Mediterranean area (northern border of the western Mediterranean), which is characterized by a limited number of rodent taxa during the whole Pleistocene. In the Italian Peninsula those taxa are certainly present, even in a limited number if compared with the Iberian Peninsula (Agustí & Moyá 1992). The Plio-Pleistocene micromammal assemblages of Italian mainland are indeed paleobiogeographically characterized by the presence, during certain moments, of some typical elements of the Mediterranean area, such as some species of the genus *Terricola*, *Talpa romana* and some Iberoccitan species (*Mimomys medasensis*, *Microtus* (*Allophaiomys*) *chalinei*, *Microtus (Iberomys) brecciensis*, and, perhaps, *Mimomys blanci*).

The renewal of Italian micromammal faunas in the great part of its elements, takes place through the north-eastern area, which first constituted the northern border of the Padanian Gulf and later on, during the maximum extension of glaciers, comprised also the area nowadays occupied by the northern Adriatic Sea. Central - Eastern Europe species expand on the whole peninsular territory, while other taxa, linked to colder climates, reach north-eastern Italy during the climatic deterioration maximums. Some of them reach central Italy, while others stop in the north-eastern area that seems to constitute a transitional area between the Mediterranean and central Europe. In north-eastern Italy the presence of a Balkan element such as

Dinaromys is almost constant. Even a few rare African elements (*Crocidura*) or Anatolian-Balkan elements (*Apodemus mystacinus*, if its origin is really in the same area where it is nowadays widespread) reach Italian Peninsula from the north-east.

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APPENDIX List of Italian mainland Plio-Pleistocene localities, with taxa and references updated to May 2001.

EARLY VILLÁNYIAN LOCALITIES

?BARGA (TUSCANY, CENTRAL ITALY) (Kotsakis 1986)
Hystrix sp.
RDB QUARRY (PIEDMONT, NORTH-WESTERN ITALY) (Argenti 1999)
Castor sp., *Apodemus alsomyoides*
CASCINA ARONDELLI (PIEDMONT, NORTH-WESTERN ITALY) (Berzi 1967; Berzi *et al.* 1967; Michaux 1970; Masini & Torre 1987; Fejfar 2001)
Blarinoides mariae, Deinsdorfia cf. *D. hibbardi*, cf. *Asoriculus gibberodon*, *Sorex* n.sp.?, *Petenyia hungarica*, *Beremendia fissidens*, *Talpa* cf. *T. minor* vel *T. fossilis*, Chiroptera indet., Sciuridae sp. I (Sciuroptera), Sciuridae sp. II, *Castor* sp., *Germanomys* sp., *Mimomys (Cseria) stehlini*, *Mimomys hassiacus*, *Apodemus alsomyoides*, *Muscardinus* cf. *M. pliocaenicus*, *Glirulus pusillus*, ?*Hystrix* sp. *Prolagus savagei*, *Hypolagus* cf. *H. brachygnathus*
ARCILLE (TUSCANY, CENTRAL ITALY) (Hürzeler & Engesser 1976; Masini & Torre 1987; Engesser 1989; Fanfani 2000)
Blarinoides sp., *Mimomys hassiacus*, Muridae gen. et sp. indet. I, Muridae gen. et sp. indet. II, *Prolagus* sp.
S. GIUSTO (TUSCANY, CENTRAL ITALY) (Kormos 1931; Masini & Torre 1987)
Mimomys (*Cseria*) *stehlini*
SPOLETO (UMBRIA, CENTRAL ITALY) (Clerici 1894; Barisone *et al.* in press)
Castor sp.

LATE VILLÁNYIAN LOCALITIES

UPPER VALDARNO (TUSCANY, CENTRAL ITALY) (Abbazzi unpublished data)
Mimomys polonicus
BOCCHIGNANO (LATIUM, CENTRAL ITALY) (Tuccimei 1893; Kotsakis 1988)
Mimomys cf. *M. polonicus*
VINCI (TUSCANY, CENTRAL ITALY) (Marcolini 2002)
Germanomys sp.
TOPPETTI QUARRY (UMBRIA, CENTRAL ITALY) (Abbazzi *et al.* 1997; Argenti 1999)
Apodemus dominans
RIVOLI VERONESE (VENETO, NORTH-EASTERN ITALY) (Sala *et al.* 1994; Sala 1996a; Fanfani & Masini, 1997)
Erinaceus sp., *Sorex bor*, *Sorex (Drepanosorex) praearaneus*, *Petenyia hungarica*, *Beremendia fissidens*, *Asoriculus gibberodon*, *Talpa* gr. *T. minor* - *T. caeca*, *Talpa* sp., *Sciurus* sp., Sciuroptera indet., *Ungaromys* sp., cf. *Ellobius* sp., *Villányia* cf. *V. exilis*, *Dinaromys allegranzii*, *Mimomys* cf. *M. pliocaenicus*, *Mimomys tornensis*, *Mimomys pitymyoides* (= *Pitymimomys pitymyoides* after Tesakov 1998), *Apodemus dominans*, *Muscardinus pliocaenicus*, *Glis minor*, *Eliomys* sp.
VALLE CATENACCIO (LATIUM, CENTRAL ITALY) (Masini *et al.* 1996)
Castor sp.
COSTA S. GIACOMO (LATIUM, CENTRAL ITALY) (*Masini et al.* 1996)
Hystrix cf. *H. refossa*
OLIVOLA (TUSCANY, CENTRAL ITALY) (Bosco, 1898; Azzaroli 1998)
Hystrix cf. *H. refossa*
CASTELFRANCO DI SOPRA (TUSCANY, CENTRAL ITALY) (Major 1902)
Mimomys pliocaenicus
UPPER VALDARNO, SEVERAL SITES OF OLIVOLA F.U. (TUSCANY, CENTRAL ITALY) (Bosco 1898; Rook & Masini, 1990; Torre *et al.* 1996; Azzaroli 1998; Fanfani, 2000)
?Erinaceus praeglacialis, *Hystrix refossa*, *Prolagus* sp., *Oryctolagus lacosti* (the fossils classifed as *Lepus etruscus* and *Lepus valdarnensis*, cf. Forteleoni 1971, have been classified as *Oryctolagus lacosti* by Lopez 1977)
PANTALLA (UMBRIA, CENTRAL ITALY) (Gentili *et al.* 1997)
Apodemus dominans
MONTAGNOLA SENESE (TUSCANY, CENTRAL ITALY) (Fondi 1972; Maul *et al.* 1998; Fanfani 2000)
Crocidura kornfeldi, *Sorex bor*, *Talpa minor*, *Myotis blythi*, *Myotis* gr. *M. schaubi* - *M. rapax*, *Myotis* sp., ?*Tadarida* sp., *Mimomys pitymyoides*, *Mimomys* sp. (large size), *Apodemus mystacinus*, *Muscardinus* sp., *Prolagus* sp., *Oryctolagus lacosti*

CASA SGHERRI (TUSCANY, CENTRAL ITALY) (Marcolini *et al.* 2000; Marcolini 2002)
Castor sp., *Mimomys pitymyoides*, *Mimomys pusillus*, *Mimomys ostramosensis*, *Apodemus dominans*, *Glis* sp., *Hystrix refossa*, *Oryctolagus* cf. *O. lacosti*
TORRE DI PICCHIO (UMBRIA, CENTRAL ITALY) (Girotti *et al.* 2003)
Mimomys medasensis, *Prolagus* sp., *Oryctolagus* cf. *O. lacosti*

EARLY BIHARIAN LOCALITIES

MONTE LA MESA (VENETO, NORTH-EASTERN ITALY) (Argenti 1999; Marchetti *et al.* 2000)
Erinaceus sp., *Crocidura* sp., *Beremendia fissidens*, *Petenyia hungarica*, *Asoriculus gibberodon*, *Sorex bor*, *Sorex minutus*, *Sorex praealpinus*, *Sorex* (*Drepanosorex*) *praearaneus*, Soricidae indet. I, Soricidae indet. II, *Talpa minor*, *Sciurus warthae*, Sciuridae indet., *Allocricetus bursae*, *Allocricetus ehiki*, *Pliomys episcopalis*, *Dinaromys dalmatinus*, *Mimomys tornensis*, *Mimomys pusillus*, *Mimomys* cf. *M. ostramosensis*, *Clethrionomys* sp., *Microtus* (*Allophaiomys*) gr. *M. (A.) pliocaenicus*, *Apodemus atavus*, *Glis sackdillingensis*, *Muscardinus* cf. *M. dacicus*, *Hypolagus beremendensis*
UPPER VALDARNO, SEVERAL SITES OF TASSO F. U. (TUSCANY, CENTRAL ITALY) (Bosco 1898, 1899; Torre 1985; Rook & Masini 1990; Rook & Kotsakis 1994; Torre *et al.* 1996; Azzaroli 1998)
Castor fiber, *Mimomys savini*, *Hystrix refossa*, *Prolagus* gr. *P. michauxi – P. calpensis*, *Oryctolagus lacosti*
TIBERINO BASIN, SOME LOCALITIES OF TASSO F. U. (UMBRIA, CENTRAL ITALY) (Sardella *et al.* 1995)
Castor fiber
CASTEL SAN PIETRO (LATIUM, CENTRAL ITALY) (Tuccimei 1891; Barisone *et al.* in press)
Castor fiber
SAVIGNANO SUL PANARO (EMILIA, NORTHERN ITALY) (Cremaschi & Sala 1982)
Mimomys sp.
STEGGIO BASIN (VENETO, NORTH-EASTERN ITALY) (Paronuzzi 1994)
Pliomys episcopalis, *Mimomys* sp., *Glis minor*
PIETRAFITTA (UMBRIA, CENTRAL ITALY) (Gentili *et al.* 1996; Argenti 1999; Barisone *et al.* in press; Argenti & Kotsakis in press)
Sorex cf. *S.minutus*, *Castor fiber*, *Borsodia* sp., *Mimomys pusillus*, *Microtus* (*Allophaiomys*) *chalinei*, *Microtus* (*Allophaiomys*) cf. *M. (A.) ruffoi*, *Oryctolagus lacosti*
SCOPPITO (ABRUZZI, CENTRAL ITALY) (Masini *et al.* 1996)
Mimomys savini
LEFFE (LOMBARDY, NORTH-WESTERN ITALY) (Stehlin 1930; Masini *et al.* 1996)
Castor fiber, *Mimomys* cf. *M. savini*
PIRRO NORD (APULIA, SOUTHERN ITALY) (De Giuli & Torre 1984; De Giuli *et al.* 1987; Masini & Santini 1991; Masini *et al.* 1996; Fanfani 2000)
Erinaceus praeglacialis, *Crocidura kornfeldi*, *Crocidura* sp., *Sorex bor*, *Petenyia hungarica*, *Asoriculus* aff. *A. thenii*, *Talpa* gr. *T. minor – T. caeca*, *Rhinolophus ferrumequinum*, *Rhinolophus birzebuggensis*, *Rhinolophus euryale*, *Myotis* cf. *M. blythi*, *Myotis* sp., *Miniopterus schreibersi*, *Miniopterus* n. sp., *Microtus* (*Allophaiomys*) cf. *M. (A.) ruffoi*, *Apodemus flavicollis*, *Muscardinus* cf. *M. avellanarius*, *Eliomys* sp., *Hystrix* cf. *H. refossa*, *Oryctolagus lacosti*, *Hypolagus brachygnathus*
PALENA (ABRUZZI, CENTRAL ITALY) (Kotsakis *et al.* 1992 and unpublished data)
Microtus (*Allophaiomys*) cf. *M. (A.) ruffoi*, *Apodemus flavicollis*, *Glis sackdillingensis*
SOAVE CAVA SUD (VENETO, NORTH-EASTERN ITALY) (Pasa 1947; Bartolomei 1980; Masini & Santini 1991; Fanfani 2000)
Crocidura zorzii, *Asoriculus castellarinii*, *Neomys* aff. *N. newtoni*, *Sorex (Drepanosorex) praearaneus*, *Sorex bor*, *Beremendia fissidens*, *Petenyia hungarica*, *Talpa* gr. *T. minor – T. caeca*, *Pliomys episcopalis*, *Mimomys* cf. *M. savini*, ?*Mimomys reidi*, *Microtus* (*Allophaiomys*) *ruffoi*, *Apodemus* gr. *A. sylvaticus – A. flavicollis*
COLLARMELE (ABRUZZI, CENTRAL ITALY) (Esu *et al.* 1991)
Microtus (*Allophaiomys*) sp.
COLLE CURTI (MARCHE, CENTRAL ITALY) (Ficcarelli *et al.* 1990; Torre *et al.* 1996; Abbazzi *et al.* 1998; Masini *et al.* 1998)
Pliomys lenki, *Microtus* (*Allophaiomys*) sp.
MONTE PEGLIA (UMBRIA, CENTRAL ITALY) (Van der Meulen 1973; Masini *et al.*, 1998; Argenti 1999)
Sorex runtonensis, *Beremendia fissidens*, *Asoriculus* cf. *A. castellarini*, *Neomys* cf. *N. newtoni*, *Talpa* cf. *T. fossilis*, *Ungaromys nanus* (= *Ungaromys meuleni* after Rabeder 1981), *Pliomys episcopalis*, *Mimomys savini*, *Mimomys blanci*, *Microtus* (*Allophaiomys*) *nutiensis*,

Microtus (*Allophaiomys*) *burgondiae*, *Apodemus* cf. *A. sylvaticus*, *Apodemus* cf. *A. maastrichtiensis*, *Apodemus* sp., *Glirulus* sp.

FONTIGNANO (ROME, LATIUM, CENTRAL ITALY) (Kotsakis *et al.* 1992; Barisone & Kotsakis, 2001)
Prolagurus pannonicus, *Predicrostonyx* sp.

LATE BIHARIAN LOCALITIES

SLIVIA (VENEZIA GIULIA, NORTH-EASTERN ITALY) (Ambrosetti *et al.* 1979; Bon *et al.* 1991; Gliozzi *et al.* 1997)
Rhinolophus ferrumequinum, *Miniopterus schreibersi*, Chiroptera indet., *Castor fiber*, *Allocricetus bursae*, *Mimomys savini*, *Dinaromys* sp., *Neodon gregaloides*, *Lepus* sp.

MONTE TENDA (VENETO, NORTH-EASTERN ITALY) (Bon *et al.* 1991; Masini *et al.* 1996)
Pliomys episcopalis, *Mimomys savini*, *Microtus* (*Microtus*) sp., *Terricola* sp.

SANT'ARCANGELO (LUCANIA, SOUTHERN ITALY) (Fanfani 2000; Masini *et al.* 2000)
Crocidura kornfeldi, *Sorex* gr. *S. subaraneus – S. runtonensis*, *Macroneomys brachygnathus*, *Talpa* cf. *T. romana*, *Allocricetus* sp., *Pliomys* sp., *Mimomys* cf. *Mimomys savini*, *Microtus (Iberomys)* cf. *M. (I.) brecciensis*, *Terricola arvalidens*, *Apodemus* sp., Leporidae indet.

EARLY TORINGIAN LOCALITIES

ISERNIA (MOLISE, SOUTHERN ITALY) (Coltorti *et al.* 1982; Sala 1983, 1996b; Coltorti *et al.* 2000)
Crocidura sp., *Sorex* cf. *S. runtonensis*, *Talpa* gr. *T. minor – T. caeca*, *Pliomys episcopali*s, *Pliomys lenki*, *Clethrionomys glareolus*, *Microtus arvalinus*, *Microtus (Iberomys) brecciensis*, *Terricola* gr. *T. multiplex – T. subterraneus*, *Arvicola cantianus*, *Lepus* sp.

BORGIO VEREZZI (VALDEMINO, LIGURIA, NORTH-WESTERN ITALY) (Nocchi & Sala 1997a, 1997b; Fanfani 2000)
Erinaceus europaeus, *Crocidura leucodon*, *Crocidura* sp., *Sorex* gr. *S. subaraneus – S. runtonensis*, *Sorex minutus*, *Talpa europaea*, *Talpa* gr. *T. minor – T. caeca*, *Allocricetus bursae*, *Pliomys episcopalis*, *Clethrionomys* sp., *Microtus (Iberomys) brecciensis*, *Terricola* sp., *Apodemus* sp., *Lepus* sp., *Oryctolagus burgi*

PONTE GALERIA , UPPER LEVELS (LATIUM, CENTRAL ITALY) (Unpublished data)
Allocricetus bursae, *Terricola* sp.

TRE FOSSI (APULIA, SOUTHERN ITALY) (Fanfani 2000 and unpublished data)
Erinaceus praeglacialis, *Crocidura kornfeldi*, *Allocricetus bursae*

VISOGLIANO, SHELTER A (VENEZIA GIULIA, NORTH-EASTERN ITALY) (Bartolomei *et al.* 1976b; Bartolomei & Tozzi, 1978; Catani *et al.* 1991; Fanfani 1998, 2000)
Erinaceus europaeus, *Crocidura kornfeldi*, *Sorex* gr. *S. subaraneus – S. runtonensis*, *Macroneomys* sp., *Talpa romana*, *Talpa fossilis*, *Talpa* gr. *T. minor – T. caeca*, *Citellus* sp., *Allocricetus bursae*, *Cricetus cricetus*, *Pliomys episcopalis*, *Dinaromys bogdanovi*, *Microtus* gr. *M. arvalis – M. agrestis*, *Microtus (Stenocranius) gregalis*, *Chionomys nivalis*, *Arvicola cantianus*, *Apodemus* sp., *Ochotona* sp.

VENOSA – NOTARCHIRICO (LUCANIA, SOUTHERN ITALY) (Sala 1989, 1999)
Sorex cf. *S. runtonensis*, *Talpa* sp., *Pliomys episcopalis*, *Microtus* aff. *M. arvalis*, *Terricola* sp., *Chionomys nivalis*, *Arvicola cantianus*, *Apodemus* sp.

POGGITAZZI (TUSCANY, CENTRAL ITALY) (Torre 1985)
Arvicola cantianus

MONTE DEL CROS (PIEDMONT, NORTH-WESTERN ITALY) (Giacobini *et al.* 1980)
Sorex runtonensis, *Talpa minor*, *Pliomys episcopalis*, *Pliomys lenki*, *Glis* sp., *Hystrix* sp. (= ? *Hystrix vinogradovi*)

FONTANA RANUCCIO (LATIUM, CENTRAL ITALY) (Masini *et al.* 1996)
Lepus sp., *Castor fiber*

CAMPANI QUARRY (TUSCANY CENTRAL ITALY) (Marcolini *et al.* 2000; Marcolini 2002)
Crocidura sp., *Clethrionomys* sp., *Terricola* gr. *T. savii*, *Terricola* aff. *T. thomasi*, *Arvicola* cf. *A. cantianus*, *Apodemus* cf. *A. sylvaticus*, *Muscardinus avellanarius*

CASE PICCONETTO (ABRUZZI, CENTRAL ITALY) (Marcolini *et al.* 2000)
Crocidura sp., *Terricola* gr. *T. savii*, *Apodemus* gr. *A. sylvaticus – A. flavicollis*

BOSCOCHIESANUOVA (VENETO, NORTH-EASTERN ITALY) (Bartolomei & Pasa 1969; Bon *et al.* 1991; Fanfani 2000)
Crocidura zorzii, *Sorex* gr. *S. subaraneus – S. runtonen-*

sis, *Macroneomys* sp., *Talpa* gr. *T. minor– T. caeca*, *Talpa europaea Cricetus cricetus*, *Pliomys episcopalis*, *Pliomys lenki*, *Dinaromys bogdanovi*, *Microtus* gr. *M. arvalis*, *Terricola* sp., *Apodemus* sp., *Glis glis*

SAN GIOVANNI DI DUINO (VENEZIA GIULIA, NORTH-EASTERN ITALY) (Bartolomei 1976; Bon *et al.* 1991; Fanfani 2000)

Crocidura sp., *Sorex* gr. *S. subaraneus – S. runtonensis*, *Macroneomys* sp., *Talpa* caeca, *Pliomys episcopalis*, *Dinaromys* cf. D. *dalmatinus*, *Dinaromys bogdanovi*, *Clethrionomys* sp., *Microtus agrestis*, *Microtus* gr. *M. arvalis*, *Terricola* gr. *T. savii*, *Chionomys nivalis*, *Arvicola* sp., *Apodemus sylvaticus*, *Glis glis*

SPESSA II (VENETO, NORTH-EASTERN ITALY) (Bartolomei 1964, 1969; Bon *et al.* 1991; Argenti & Kotsakis 1999)

Erinaceus europaeus, *Crocidura* sp., *Sorex* gr. *S. subaraneus – S. runtonensis*, *Talpa* gr. *T. minor – T. caeca*, *Talpa europaea*, *Allocricetus bursae*, *Pliomys episcopalis*, *Clethrionomys* gr. *C. glareolus*, *Microtus agrestis*, *Terricola* sp., *Arvicola* cf. *A. cantianus*, *Apodemus sylvaticus*, *Apodemus* cf. *A. microps*, *Glis glis*, *Lepus* sp.

SAN VITO DI LEGUZZANO 2 (VENETO, NORTH-EASTERN ITALY) (Bartolomei 1966a, 1969; Bon *et al.* 1991; Fanfani 2000)

Neomys sp., *Macroneomys* sp., *Talpa* cf. *T. europaea*, *Allocricetus bursae*, *Pliomys episcopalis*, *Dinaromys bogdanovi*, *Clethrionomys* gr. C. *glareolus*, *Microtus* sp., *Terricola* sp., *Apodemus* sp.

FONTANA MARELLA, LOWER LEVELS (LOMBARDY, NORTH-WESTERN ITALY) (Tintori *et al.* 1995)

Pliomys episcopalis, *Dinaromys bogdanovi*

CAMPO DEI FIORI (LOMBARDY, NORTH-WESTERN ITALY) (Zanalda, 1994b)

Chiroptera indet., *Dinaromys bogdanovi*, *Clethrionomys* sp., *Chionomys nivalis*, *Glis glis*

BRISTIE I (VENEZIA GIULIA, NORTH-EASTERN ITALY) (Lugli & Sala, 2000)

Dinaromys gr. *D. bogdanov*, *Lepus europaeus*

TORRE IN PIETRA, LOWER LEVELS (LATIUM, CENTRAL ITALY) (Caloi & Palombo 1978)

Castor fiber, *Glis glis*, *Lepus* sp., *Oryctolagus cuniculus*

LOARA (VENETO, NORTH-EASTERN ITALY) (Bartolomei 1966a, 1969; Bon *et al.* 1991)

Sorex gr. *S. praearaneus – S. runtonensis*, *Sorex* cf. *S. araneus*, *Sorex minutus*, *Neomys* sp., *Talpa europaea*, *Dinaromys bogdanovi*, *Clethrionomys* cf. *C. rufocanus*, *Microtus* gr. *M. arvalis – M. agrestis*, *Terricola multiplex*, *Arvicola* sp., *Apodemus* sp.

SANT'AGOSTINO (VENETO, NORTH-EASTERN ITALY) (Bartolomei 1966a, 1969; Bon *et al.* 1991)

Sorex gr. *S. praearaneus– S. runtonensis*, *Sorex araneus*, *Sorex alpinus*, *Talpa europaea*, *Clethrionomys* cf. C. *rufocanus*, *Microtus* gr. *M. arvalis – M. agrestis*, *Arvicola* sp., *Apodemus* sp.

LATE TORINGIAN LOCALITIES

TORRENTE CONCA (MARCHE, CENTRAL ITALY) (Conti *et al.* 1982)

Castor fiber, *Clethrionomys* sp., *Microtus* gr. *M. arvalis – M. agrestis*, *Arvicola* sp.

GROTTA MAGGIORE DI SAN BERNARDINO (VENETO, NORTH-EASTERN ITALY) (Bartolomei 1960, 1969; Bon *et al.* 1991)

Talpa europaea, *Marmota marmota*, *Cricetus cricetus*, *Dinaromys bogdanovi*, *Clethrionomys* sp., *Microtus agrestis*, *Arvicola* sp., *Glis glis*, *Dryomys nitedula*, *Lepus* sp.

GROTTA DI SAN LEONARDO (VENEZIA GIULIA, NORTH-EASTERN ITALY) (Bartolomei 1982; Bon *et al.* 1991)

Crocidura sp., *Marmota marmota*, *Cricetus cricetus*, *Pliomys lenki*, *Dinaromys bogdanovi*, *Microtus arvalis*, *Microtus oeconomus*, *Chionomys nivalis*, *Apodemus sylvaticus*, *Glis glis*

GROTTA DEL VENTO (MARCHE, CENTRAL ITALY) (Esu *et al.* 1990)

Sorex araneus, *Sorex minutus*, *Rhinolophus ferrumequinum*, *Myotis dasycneme*, *Pliomys lenki*, *Microtus arvalis*, *Chionomys nivalis*, *Apodemus* cf. *A. sylvaticus*

TORRE IN PIETRA, UPPER LEVELS (LATIUM, CENTRAL ITALY) (Caloi & Palombo 1978)

Erinaceus europaeus, *Clethrionomys glareolus*, *Microtus* gr. *M. arvalis – M. agrestis*, *Arvicola terrestris*, *Apodemus* gr. *A. sylvaticus – A. flavicollis*) *Glis glis*, *Oryctolagus cuniculus*

GROTTA DEL PRINCIPE, LOWER LEVELS (LIGURIA, NORTH-WESTERN ITALY) (Barral & Simone 1971)

Microtus arvalis, *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Oryctolagus cuniculus*

GROTTA PAGLICCI, OUTER LEVELS (APULIA SOUTHERN ITALY) (Bartolomei 1980; Galiberti 1984)

Allocricetus bursae, *Microtus brecciensis*, *Microtus arvalis*, *Terricola savii*, *Arvicola* sp., *Apodemus* sp., *Eliomys* sp., *Hystrix* sp., *Oryctolagus* sp.

MONTORIO (VENETO, NORTH-EASTERN ITALY) (Pasa 1951; Bartolomei 1980; Bon *et al.* 1991)

Erinaceus europaeus, *Crocidura zorzii*, *Crocidura* cf. *C. suaveolens*, *Sorex alpinus*, *Talpa europaea*, *Clethrionomys glareolus*, *Microtus agrestis*, *Microtus* cf. *M. arvalis*, *Terricola multiplex*, *Chionomys nivalis*, *Arvicola* sp., *Apodemus sylvaticus*, *Glis glis*, *Lepus europaeus*

PIANICO SELLERE (LOMBARDY, NORTH-WESTERN ITALY) (Lona & Venzo 1957)

Dryomys nitedula

SAN SIDERO 3 (APULIA, SOUTHERN ITALY) (De Giuli 1983)

Microtus cf. *M. agrestis*, *Terricola savii*, *Apodemus sylvaticus*, *Eliomys quercinus*, *Oryctolagus cuniculus*

GROTTA DI SCARIO, LEVEL A (CAMPANIA, SOUTHERN ITALY) (Ronchitelli *et al.* 1998; Fanfani 2000)

Crocidura zorzii, *Crocidura* sp., *Sorex runtonensis*, *Talpa europaea*, *Terricola savii*, *Terricola subterraneus*, *Arvicola* aff. *A. terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Lepus europaeus*

GROTTA DI SANT'AGOSTINO (LATIUM, CENTRAL ITALY) (Tozzi, 1970)

Erinaceus europaeus, *Talpa romana*, *Rhinolophus ferrumequinum*, *Myotis blythi*, *Marmota marmota*, *Cricetus cricetus*, *Microtus arvalis*, *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys* cf. *E. quercinus*, *Lepus europaeus*, *Oryctolagus cuniculus*

GROTTA DEL BROION (VENETO, NORTH-EASTERN ITALY) (Pasa 1953; Sala 1980, 1990; Zanalda 1994a)

Sorex araneus, *Marmota marmota*, *Sicista* sp., *Cricetus cricetus*, *Clethrionomys glareolus*, *Dinaromys* gr. *D. bogdanovi*, *Microtus agrestis*, *Microtus arvalis*, *Chionomys nivalis*, *Terricola* sp., *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Muscardinus avellanarius*, *Dryomys nitedula*, *Lepus europaeus*

GROTTA A DI VEJA (VENETO, NORTH-EASTERN ITALY) (Pasa 1950; Bartolomei & Broglio 1975; Sala 1990; Bon *et al.* 1991)

Erinaceus europaeus, *Sorex araneus*, *Neomys fodiens*, *Talpa europaea*, *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, *Rhinolophus mehelyi*, *Myotis bechsteini*, *Myotis dasycneme*, *Myotis myotis*, *Myotis blythi*, *Eptesicus nilssoni*, *Nyctalus noctula*, *Miniopterus schreibersi*, *Marmota marmota*, *Sicista betulina*, *Cricetus cricetus*, *Clethrionomys glareolus*, *Pliomys lenki*, *Dinaromys* gr. *D. bogdanovi*, *Microtus* gr. *M. arvalis*, *Microtus agrestis*, *Microtus (Stenocranius) gregalis*, *Microtus oeconomus*, *Chionomys nivalis*, *Terricola multiplex*, *Terricola* sp., *Arvicola terrestris*, *Apodemus* sylvaticus, *Lepus* cf. *L. europaeus*, *Lepus* sp.

MEZZENA SHELTER (VENETO, NORTH-EASTERN ITALY) (Bartolomei *et al.* 1980; Sala 1990; Bon *et al.* 1991)

Sorex araneus, *Neomys* sp., *Talpa europaea*, *Talpa* sp., *Rhinolophus* cf. *R. euryale*, *Myotis* cf. *M. dasycneme*, *Myotis myotis*, *Myotis blythi*, *Marmota marmota*, *Sicista betulina*, *Cricetus cricetus*, *Clethrionomys glareolus*, *Clethrionomys* sp., *Microtus agrestis*, *Microtus arvalis*, *Microtus* (*Stenocranius) gregalis*, *Chionomys nivalis*, *Terricola multiplex*, *Arvicola terrestris*, *Glis glis*, *Muscardinus avellanarius*, *Eliomys* cf. *E. quercinus*, *Lepus europaeus*

GHIACCIAIA SHELTER (VENETO, NORTH-EASTERN ITALY) (Bartolomei *et al.* 1984; Ferraris *et al.* 1990; Sala 1990; Bon *et al.* 1991)

Sorex araneus, *Sorex* sp., *Talpa europaea*, *Marmota marmota*, *Dinaromys* gr. *D. bogdanovi*, *Microtus* gr. *M. arvalis - M. agrestis*, *Microtus* sp., *Chionomys nivalis*, *Terricola* sp., *Arvicola terrestris*, *Apodemus* gr. *A. sylvaticus - A. flavicollis*, *Glis glis*, *Eliomys quercinus*

TAGLIENTE SHELTER, LOWER LEVELS (VENETO, NORTH-EASTERN ITALY) (Bartolomei *et al.* 1982; Sala 1990; Bon *et al.* 1991)

Crocidura sp., *Sorex araneus*, *Sicista* sp., *Cricetus cricetus*, *Clethrionomys* sp., *Dinaromys* gr. *D. bogdanovi*, *Microtus agrestis*, *Microtus arvalis*, *Microtus (Stenocranius) gregalis*, *Microtus oeconomus*, *Chionomys nivalis*, *Arvicola* sp., *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Dryomys nitedula*, *Ochotona* cf. *O. pusilla*

GROTTA DELLA FERROVIA (MARCHE, CENTRAL ITALY) (Bartolomei 1966b)

Sorex araneus, *Sorex minutus*, *Crocidura leucodon*, *Rhinolophus ferrumequinum*, *Rhinolophus* spp., *Myotis* sp., *Nyctalus noctula*, *Sicista betulina*, *Clethrionomys* sp., *Microtus* gr. *M. arvalis - M. agrestis*, *Microtus* gr. *M. oeconomus*, *Chionomys nivalis*, *Terricola* sp.

GROTTA CALA (CAMPANIA, SOUTHERN ITALY) (Bartolomei *et al.* 1976a, 1977)

Sorex araneus, *Sorex minutus*, *Talpa caeca*, *Talpa roma-*

na, *Clethrionomys glareolus*, *Microtus arvalis*, *Microtus agrestis*, *Terricola savii*, *Arvicola* sp., *Apodemus* sp., *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*

GROTTA DI CASTELCIVITA (CAMPANIA, SOUTHERN ITALY) (Cioni *et al.* 1979; Masini & Abbazzi 1997; Fanfani 2000)

Erinaceus europaeus, *Talpa* gr. *T. minor – T. caeca*, *Talpa romana*, *Sorex araneus*, *Sorex minutus*, *Myotis* cf. *M. myotis*, *Myotis* sp., *Miniopterus schreibersi*, Vespertilionidae indet., *Clethrionomys glareolus*, *Microtus arvalis*, *Microtus agrestis*, *Chionomys nivalis*, *Terricola savii*, *Terricola* gr. *T. multiplex – T. subterraneus*, *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*, *Lepus europaeus*

MONCUCCO TORINESE (PIEDMONT, NORTH-WESTERN ITALY) (Alessio *et al.* 1982)

Sorex araneus, *Talpa europaea*, *Clethrionomys* cf. *C. glareolus*, *Microtus arvalis*, *Microtus agrestis*, *Terricola* cf. *T. savii*, *Arvicola* cf. *A. terrestris*, *Apodemus sylvaticus*, *Glis glis*

GROTTA BREUIL (LATIUM, CENTRAL ITALY) (Kotsakis, 1991)

Crocidura suaveolens, *Rhinolophus ferrumequinum*, *Miniopterus schreibersi*, *Myotis myotis*, *Nyctalus noctula*, *Tadarida teniotis*, *Terricola* cf. *T. savii*, *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Dryomys nitedula*

PRAIA A MARE (CALABRIA, SOUTHERN ITALY) (Capasso Barbato & Gliozzi 2001)

Sorex araneus, *Sorex minutus*, *Clethrionomys glareolus*, *Microtus arvalis*, *Microtus agrestis*, *Terricola savii*, *Arvicola terrestris*, *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*

GROTTA PAGLICCI, INNER LEVELS (APULIA, SOUTHERN ITALY) (Bartolomei 1975; Bartolomei *et al.* 1977)

Sorex araneus, *Sorex minutus*, *Talpa romana*, *Clethrionomys glareolus*, *Microtus* gr. *M. arvalis*, *Microtus agrestis*, *Chionomys nivalis*, *Terricola savii*, *Arvicola* sp., *Apodemus sylvaticus*, *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*, *Lepus* sp.

TAGLIENTE SHELTER, UPPER LEVELS (VENETO, NORTH-EASTERN ITALY) (Capuzzi & Sala 1980; Sala 1990; Bon *et al.* 1991)

Erinaceus europaeus, *Sorex araneus*, *Sorex minutus*, *Crocidura* sp., *Talpa europaea*, *Marmota marmota*, *Castor fiber*, *Sicista* sp., *Dinaromys bogdanovi*, *Microtus* gr. *M. arvalis – M. agrestis*, *Chionomys nivalis*, *Arvicola terrestris*, *Terricola savii*, *Apodemus* gr. *A. sylvaticus – A. flavicollis*, *Glis glis*, *Eliomys quercinus*, *Dryomys nitedula*, *Lepus europaeus*, *Lepus* cf. *L. timidus*, *Oryctolagus cuniculus*

GROTTA DELLA SERRATURA (CAMPANIA, SOUTHERN ITALY) (Bertolini *et al.* 1996)

Erinaceus europaeus, *Crocidura suaveolens*, *Sorex* sp., *Talpa romana*, *Talpa caeca*, *Clethrionomys glareolus*, *Microtus arvalis*, *Microtus agrestis*, *Terricola savii*, *Chionomys nivalis*, *Arvicola terrestris*, *Apodemus* gr. *A. sylvaticus - A. flavicollis*, *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*