

Late Pliocene and Pleistocene small mammal chronology in the Italian peninsula

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Abstract

The abundant documentation of small mammals in the Italian peninsula, collected over recent years, furnishes a detailed biochronological sequence mainly from the Late Pliocene onwards. An updated stratigraphic framework is here presented, based on the European small mammal biozonation. The Early Villanyian is characterized by *Mimomys hassiacus*, *M. stehlini*, and, later, poorly documented *M. polonicus*. The Late Villanyian localities are well characterized with *M. pliocaenicus*, *M. pitymyoides* and *M. tigliensis*. The older part of the Early Biharian is documented by assemblages containing *Microtus (Allophaiomys)* ex gr. *pliocaenicus*, *M. pusillus*, *M. cf. ostramosensis* and *M. tornensis*, while the later part of the Early Biharian, is characterized by advanced *Microtus (Allophaiomys)* species occurring together with *M. pusillus* or *M. blanci*. In the Late Biharian *M. savini*, *Microtus hintoni-gregaloides*, *Microtus (Iberomys)* ex gr. *huescarensis-brecciensis* and *Terricola arvalidens* occur. The Early Toringian with *A. mosbachensis*, *Allocricetus bursae*, *Pliomys episcopalis* and small-sized *Microtus brecciensis*, and the Late Toringian with *A. terrestris* in diversified associations are quoted. The most important faunal events are calibrated by independent chronological controls, thanks to the record of small mammals from lacustrine deposits. Several figures illustrate the most significant rodent species occurring in the succession of selected Italian localities.

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1. Introduction

The first pioneering works on small Italian mammals were by Tuccimei (1893), whilst other contributions were published by Forsyth Major (1913), Kormos (1931, 1933), and Stehlin (1930). Apart from several works devoted to the endemic forms of the Italian islands, the study of small mammals was begun in Italy by Pasa (1942, 1948, 1950, 1952), who mainly concentrated on sites of northeastern regions of the peninsula. Other significant contributions by Bartolomei (1960, 1964, 1966, 1970, 1980) and van der Meulen (1973) preceded a more widespread interest that began in the 1980s, thanks to several authors (De Giuli, Sala, Torre, Kotsakis, Masini). In recent decades the knowledge of the small mammalian fossil record became more consistent, following the discovery of new important localities and the sieving of sediments in many fluvial and lacustrine deposits in throughout the peninsula. These

deposits comprise the material reference of most large mammalian records and biochronology. At the same time stratigraphic and magnetostratigraphic investigations have been carried out to provide firmer chronological calibrations for both the large and small mammal chronology. At present, part of the records of small mammals came from Pliocene lacustrine deposits. The richest and most diverse record, however, is from Middle and Late Pleistocene karst deposits and cave deposits (Masini and Abbazzi, 2004). Gliozzi et al. (1997) made the first attempt to develop a stratigraphical synthesis, based on small mammals while, more recently an exhaustive detailed synthesis, focused mainly on biogeography, was presented by Kotsakis et al. (2003).

Given the large amount of information available, an updated stratigraphical framework of the small mammal occurrences in Italy is here presented and discussed. The integrated chronological scheme in Fig. 1 is arranged based on the European small mammal biozonation; the most significant faunal events are calibrated by independent chronology. In addition, illustrations of the most

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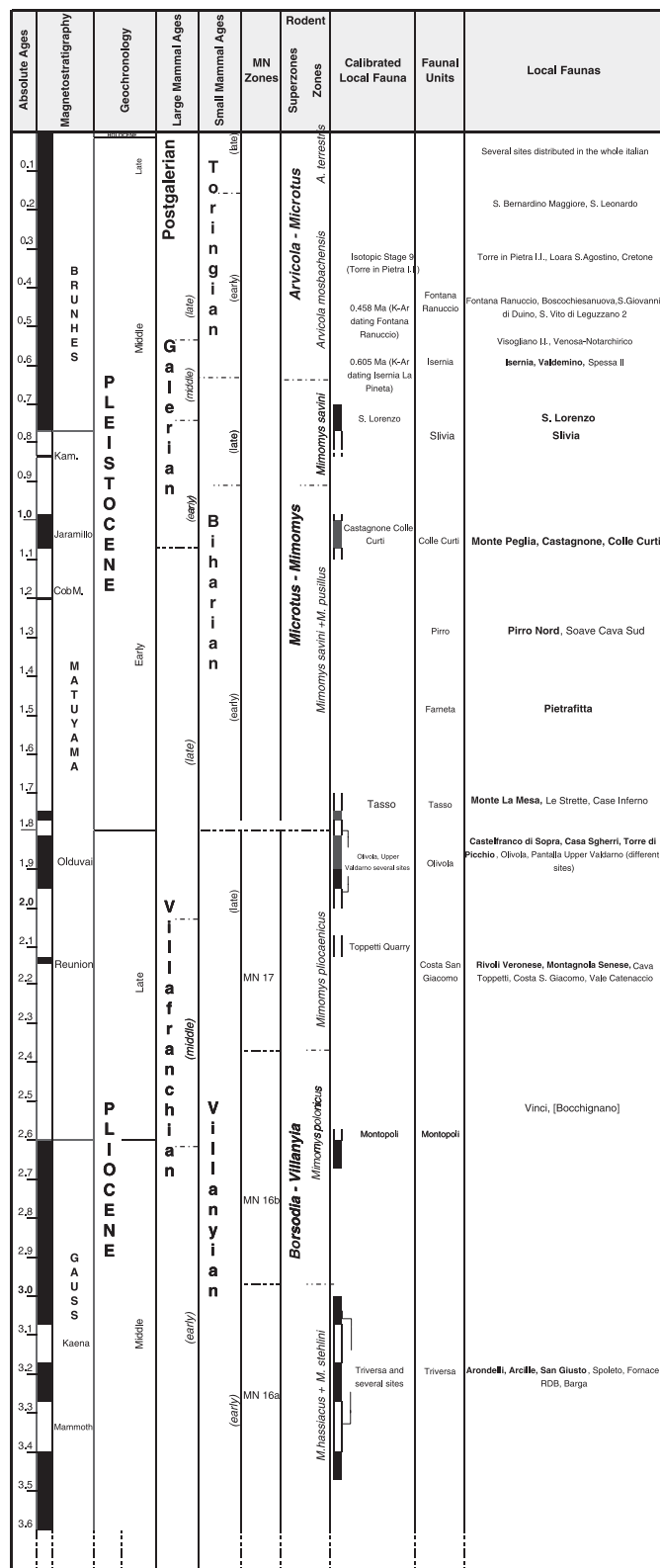


Fig. 1. An integrate chronological scheme of the local Italian faunas according to the small European mammal biozonation.

significant Arvicolinae taxa for Italy are included, to provide an immediate visual impression of the dental morphological evolution of these rodents.

2. Villanyian (Fig. 2)

The most representative Early Villanyian fauna in Italy is from Cascina Arondelli (Asti, Piedmont) which has yielded a rich fauna (Berzi et al., 1967; Fejfar, 2001; Kotsakis et al., 2003) (Fig. 3A). The Arcille (Grosseto, Tuscany; Hürzeler and Engesser, 1976) contained a small fauna that includes *Mimomys hassiacus* (Masini and Torre, 1987; Fejfar, 2001) (Fig. 3B). The well known locality of San Giusto (Lower Valdarno, Tuscany) yielded the type specimen of *M. stehlini* (Kormos, 1931; Masini and Torre, 1987) (Fig. 3C). A further three sites have provided one or two taxa: *Castor plicidens* and *Apodemus alsomyoides* from RDB (Rizzi, Donelli, Breviglieri and Co.) Quarry (Asti, Piedmont; Argenti, 1999; Barisone, 2004), *Hystrix* sp. from Barga (Lucca, Tuscany; Kotsakis, 1986), and *Castor* sp. from Spoleto (Perugia, Umbria; Clerici, 1894). These faunas are coeval with the large mammal assemblages of the Triversa Faunal Unit and are correlated to the Gauss Chron in the Triversa near Villafranca d’Asti and Castelnuovo dei Sabbioni in the Upper Valdarno localities (Lindsay et al., 1980; Napoleone et al., 2003). The reinterpretation by Lindsay et al. (1997), which considered the reverse polarity found at RDB Quarry as belonging to the uppermost Gilbert Chron, is accepted neither by Maul et al. (1998) nor Napoleone et al. (2003). In the fauna from Cascina Arondelli, seven insectivores among which



Fig. 2. Villanyian Italian sites: 1, Cascina Arondelli, RDB Quarry and Triversa, Villafranca d’Asti; 2, Arcille, Grosseto; 3, San Giusto, Empoli (Lower Valdarno); 4, Castelnuovo dei Sabbioni, Montevarchi and Calstelfranco di Sopra, Arezzo (Upper Valdarno); 5, Barga, Lucca; 6, Spoleto and Pantalla, Perugia; 7, Bocchignano, Rieti; 8, Vinci and Casa Sgherri, Florence (Lower Valdarno); 9, Rivoli Veronese, Verona; 10, Montagnola Senese, Siena; 11, Olivola, Massa; 12, Costa San Giacomo and Valle Catenaccio, Frosinone; 13, Torre di Picchio, Terni.

Blarinoides mariae and *Deinsdorfia* cf. *hibbardi*, two lagomorphs *Prolagus savagei* and *Hypolagus* cf. *beremendensis*, 10 rodents among which *Germanomys* cf. *weileri*, *M. stehlini*, *M. hassiacus*, *Apodemus alsomyoides*, and a flying squirrel and eight large mammal taxa have been identified (Ambrosetti et al., 1996).

The *M. polonicus* zone is poorly documented in Italy. *M. polonicus* is reported from Bocchignano (Rieti, Latium; Tuccimei, 1893; Kotsakis, 1988). *M. polonicus* (derived morphotype) has been recently found in sediments of the lower Montevarchi synthem (Upper Valdarno) where reversed magnetization referred to the pre-Réunion interval of the Matuyama Chron is recorded (Napoleone et al., 2003; Ghinassi et al., 2004, 2005). One find of *Germanomys* sp., in association with *Equus* ex gr. *stenonis-senezensis*, is reported from Vinci (Fucecchio, Lower Valdarno) by Marcolini (2001) and Sardella et al. (2003), but it is not illustrated.

The most complete representation of the *M. pliocaenicus* zone of the Late Villanyian is found at the karstic site of Rivoli Veronese (Verona, Venetia; Sala et al., 1994; Sala, 1996b; Fanfani and Masini, 1997), and by the less diverse assemblage from site Montagnola Senese (Siena, Tuscany; Fondi, 1972; Maul et al., 1998). The Rivoli Veronese fauna, which has yielded much new material, currently under investigation by Marchetti and Sala, includes 12 insectivores and 16 rodents, including *Pliopetaurista*, *M. pliocaenicus*, *M. pitymyoides*, *M. tigliensis* (= *M. tornensis*), *Ungaromys dehmi* and *Dinaromys allegranzzii* (Fig. 3D and E; Fig. 4A). The last is the most ancient species of the genus and, at present, is known only from this site. The taxa of biogeographical significance are represented mainly by *Petenya hungarica*, *Sorex prealpinus*, *Pliomys* and *Villanyia exilis*, which, at least during this period, were found mostly in Central to Eastern Europe.

In the Upper Valdarno Basin, Castelfranco di Sopra is the type locality of *M. pliocaenicus* (Fig. 4B) (Masini and Torre, 1987), together with several large mammal sites, grouped in the Olivola Faunal Unit, are indirectly referred to the *M. pliocaenicus* zone (Rook and Masini, 1990; Torre et al., 1996; Azzaroli, 1998; Fanfani, 2000; Kotsakis et al., 2003). The sediments outcropping in these localities belong to the upper part of the Montevarchi Synthem and are directly correlated with the interval between Réunion and early part of Olduvai Subchrons (Napoleone et al., 2003).

Several other localities in Central Italy are referred to this same zone. Some of them contain very few small mammals: they lack arvicolids and their grouping in this zone is indirectly related to the occurrence of large mammals of the Olivola or Costa San Giacomo Faunal Unit at sites including Olivola (Massa Carrara, Tuscany; Azzaroli, 1998), Pantalla (Perugia, Umbria; Gentili et al., 1997), Costa San Giacomo and Valle Catenaccio (Frosinone, Latium; Masini et al., 1996). At these localities two large rodent genera (*Castor* and *Hystrix*) are present, while *Apodemus dominans* has been reported from Pantalla. At the Toppetti Quarry in the

Tiberino Basin (Abbazzi et al., 1997; Argenti, 1999), sediments containing *Apodemus dominans* unconformably overlie a thick series, which dates from the latest Gauss—early Matuyama, immediately above the Réunion Subchron (Abbazzi et al., 1997). Two localities are particularly significant: the first is Casa Sgherri (Lower Valdarno, Tuscany; Marcolini et al., 2000; Marcolini, 2001) where *M. pitymyoides* and *M. pusillus* (*M. coelodus* occurs, according to Marcolini and Mountuire, 2004) are associated with the large vole *M. ostramosensis* (Fig. 4C); the other one is Torre di Picchio (Terni, Umbria; Girotti et al., 2003), where *M. medasensis* is associated with a Late Villafranchian large mammal assemblage.

Microtus (Allophaiomys) deucalion, a very primitive species, usually reported with *M. ostramosensis* in Central Europe, has not been recorded in Italy.

3. Biharian (Fig. 5)

The oldest Early Biharian locality is Monte La Mesa (Verona, Venetia; Marchetti et al., 2000), where *Microtus (Allophaiomys)* gr. *pliocaenicus* is associated with *M. pusillus*, *M. cf. ostramosensis*, and *M. tornensis* (Figs. 4D, 6A and B). This fauna is very abundant and diverse, with 12 insectivores, one lagomorph and 12 rodents, some of which, for instance *Sciurus warthae* and *Allocricetus ehiki*, have the first records from. The 580 teeth of *Apodemus atavus* represent the most abundant collection of this species in Europe.

Few remains of *M. savini* came from the Upper Valdarno (localities Case Inferno and Le Strette; Torre, 1985), where levels that yielded large mammals are typical of the Tasso Faunal Unit (FU) outcrop (Fig. 7A). These sediments have been calibrated paleomagnetically to the upper part of Olduvai and the very base of the following reverse interval of the Matuyama Chron immediately (1.8 my).

Pietrafitta (Farneta FU) (Perugia, Umbria; Gentili et al., 1996; Argenti, 1999), Cava Pirro-Dell'Erba (homonymous FU) (San Severo, Foggia, Apulia; Masini et al., 1996; Fanfani, 2000) and Soave Cava Sud (Verona, Venetia; Pasa, 1948) Masini and Santini (1991) and Fanfani (2000) represent a chronological sequence of younger Early Biharian faunas where *Microtus (A.)* gr. *ruffoi* occurs. At Pietrafitta *Microtus (Allophaiomys) chalinei* occurs together with *M. pusillus* (Fig. 7B). The faunas from Cava Pirro-Dell'Erba, although rich in microvertebrates, almost completely lack of rooted vole species (Fig. 7C). *M. savini* is not present in these two localities while has been found at Soave Cava Sud (Fig. 7D). These *Allophaiomys* have Mimomyian enamel and are not advanced forms of the subgenus (Lippi et al., 1998).

The youngest part of the Early Biharian is represented at a few sites. At Monte Peglia (Perugia, Umbria; van der Meulen, 1973; Maul et al., 1998; Argenti, 1999) two derived species of *Allophaiomys*, *M. (A.) burgondiae* and *M. (A.) nutiensis*, occur together with *M. savini*, *M. blanci* and

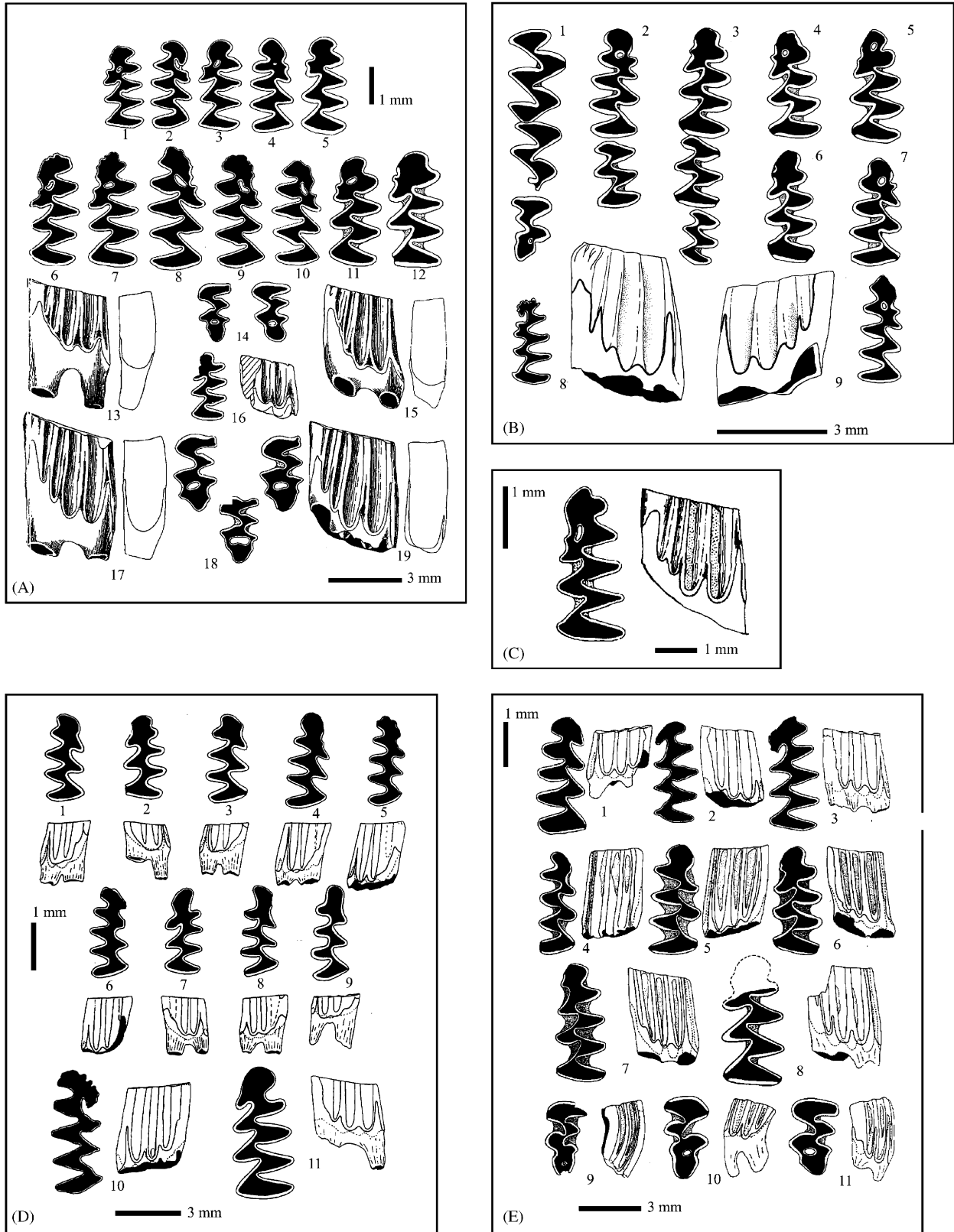


Fig. 3. (A) Arondelli: *Mimomys stehlini* (1–5, 13–15), *M. hassiacus* (6–12, 17–19), *Germanomys* cf. *weileri* (16) (from Fejfar, 2001); (B) Arcille: *M. hassiacus* (from Masini and Torre, 1987); (C) San Giusto: holotype of *M. stehlini* (from Fejfar, 2001); (D) Rivoli Veronese: *Ungaromys dehmi* (1–6), *Villanyia* cf. *exilis* (7–9), *Dinaromys allegranzii* (10–11) (from Sala et al., 1994); (E) Rivoli Veronese: *D. allegranzii* (1–3), *M. tigliensis* (4–7), *M. cf. pliocaenicus* (8–11) (from Sala et al., 1994).

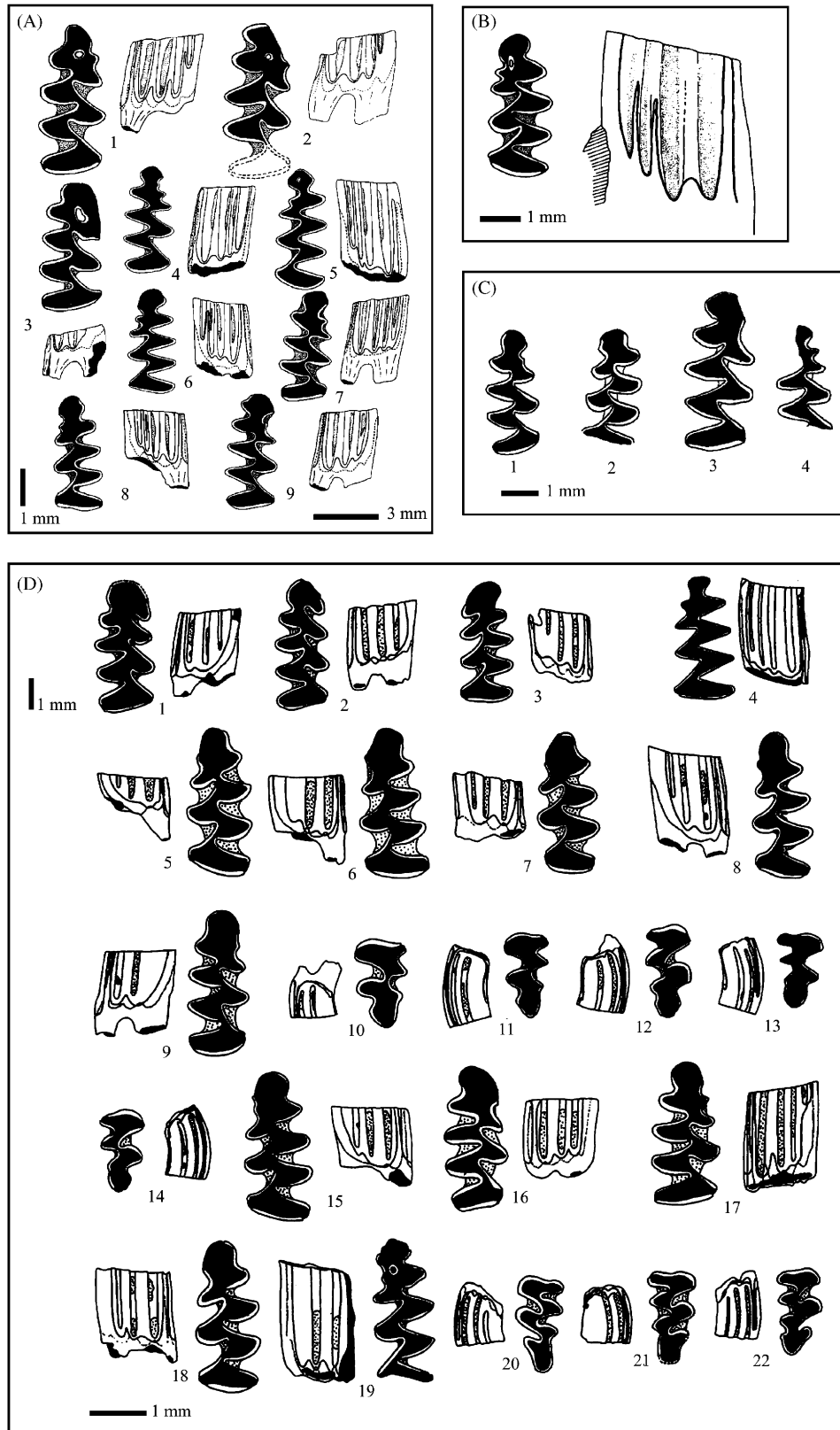


Fig. 4. (A) Rivoli Veronese: *Mimomys* cf. *pliocaenicus* (1–3), *M. pitymyoides* (4–9) (from Sala et al., 1994); (B) Castelfranco di Sopra: *M. pliocaenicus*, type specimen (from Masini and Torre, 1987); (C) Casa Sgherri: *M. pitymyoides* (1), *M. pusillus* (2), *Mimomys* sp. 1 (3), and *Mimomys* sp. 2 (4) (from Marcolini et al., 2000); (D) Monte La Mesa: *Pliomys episcopalidis* (1–9), *Dinaromys dalmatinus* (10–18) (from Marchetti et al., 2000).



Fig. 5. Biharian Italian sites: 1, Monte La Mesa, Soave Cava Sud and Monte Tenda, Verona; 2, Case Inferno, Le Strette and Il Tasso, Arezzo (Upper Valdarno); 3, Pietrafitta and Monte Peglia, Perugia; 4, Cava Pirro-Dell'Erba, Foggia; 5, Castagnone, Alessandria; 6, Colle Curti, Macerata; 7, Slivia, Trieste; 8, Rifreddo, Potenza.

U. nanus (Fig. 7E). A fauna comparable to that from Monte Peglia has recently been found at Castagnone (Alessandria, Piedmont) and includes *Microtus* (*Allophaiomys*) cf. *M. (A.) nutiensis*, *M. savini*, *M. pusillus* and *Ungaromys* cf. *U. nanus*, etc. (Giraudi et al., 2003) (Fig. 7F). At this site the sediments are normal magnetized, and have been referred to the Jaramillo Subchron. Colle Curti (homonymous FU of the early Galerian) (Macerata, Marche; Abbazzi et al., 1998; Masini et al., 1998) yielded a specimen of *M. (Allophaiomys)* sp., with a derived enamel pattern and a primitive occlusal outline, together with *Pliomys lenki* (Fig. 7G), in sediments referred to the same Jaramillo Subchron (Torre et al., 1996; Ficarelli et al., 1997). Other localities of the Early Biharian have provided poor fossil remains and are not considered here.

The Late Biharian is also represented at a few localities where *M. savini* occurs together with *Microtus* subgenera more evolved than *Allophaiomys*. In the karst breccia at Slivia (Trieste, Julian Venetia) *Microtus hintoni-gregaloides* is present together with a *Dinaromys* (Ambrosetti et al., 1979) (Fig. 7H). In the Rifreddo locality of the San Lorenzo succession, in the Sant'Arcangelo Basin (Potenza, Basilicata), the fauna, characterized by *Mimomys* cf. *M. savini*, *Microtus* (*Iberomys*) ex gr. *huescarensis-breciensis*, *Terricola arvalidens* and other rodents and

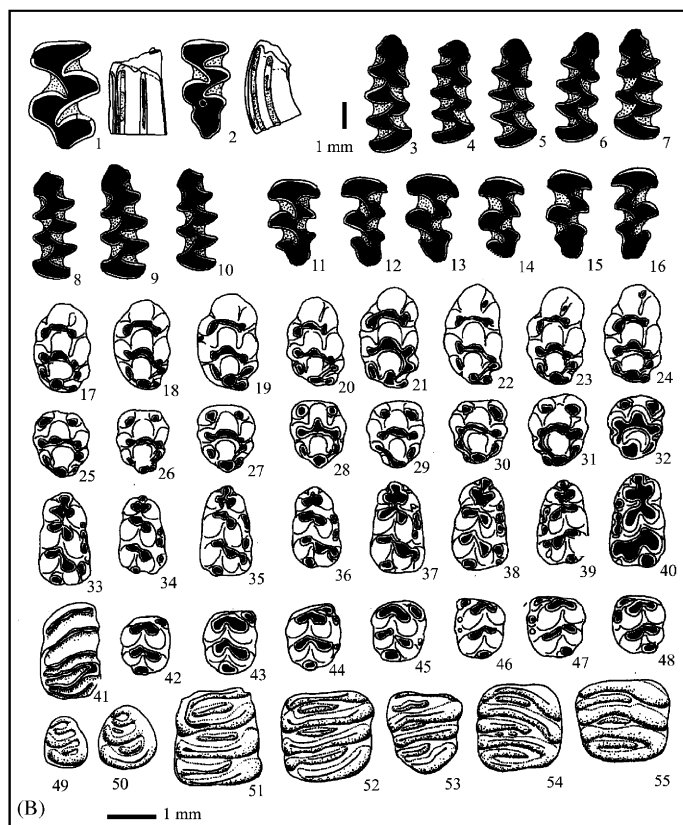
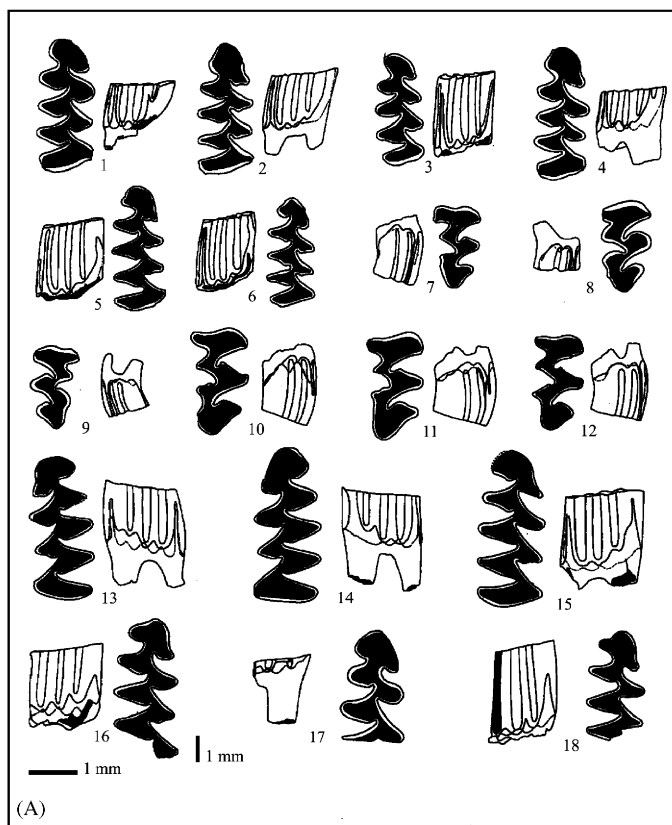


Fig. 6. (A) Monte La Mesa: *Clethrionomys* sp. (1–3), *Mimomys* cf. *malezi* (4), *M. pusillus* (5–14), *M. tornensis* (15–19) (from Marchetti et al., 2000); (B) Monte La Mesa: *M. cf. ostromosensis* (1), *Microtus* (*Allophaiomys*) gr. *pliocenicus* (3–16), *Apodemus atavus* (17–40, 42–48), *Muscardinus* cf. *dacicus* (41), *Glis sackdillingensis* (49–55) (from Marchetti et al., 2000).

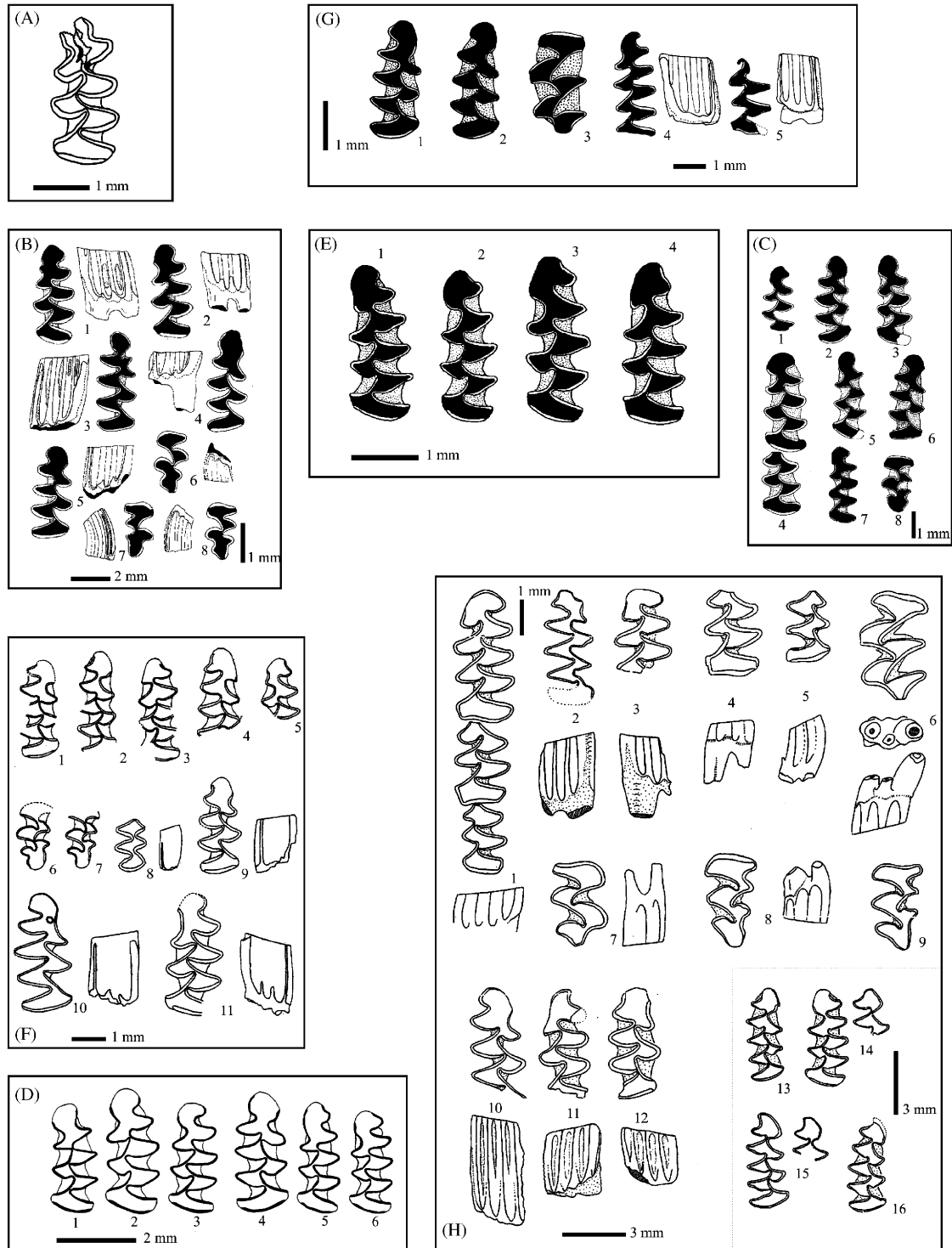


Fig. 7. (A) Le Strette: *Mimomys savini* (from Torre, 1985); (B) Pietrafitta: *M. pusillus* (from Gentili et al., 1996); (C) Pietrafitta: *Microtus (Allophaiomys)* cf. *ruffoi* (1–3 and 5–8), *M. (A.) chalinei* (4) (from Gentili et al., 1996); (D) Cava Pirro: *Microtus (Allophaiomys)* cf. *ruffoi* (from Masini and Santini, 1991); (E) Monte Peglia: *Microtus (Allophaiomys) burgondiae* (1–2), *M. (A.) nutiensis* (3–4) (from Maul et al., 1998); (F) Castagnone: *Microtus (Allophaiomys)* sp. (1–7), *Ungaromys* cf. *nanus* (8), *M. pusillus* (9), *M. savini* (10–11) (from Giraudi et al., 2003); (G) Colle Curti: *Microtus (Allophaiomys)* sp. (1–3), *Pliomys lenki* (4–5) (from Abbazzi et al., 1998); (H). Slivia: *Dinaromys* sp. (1–9), *M. savini* (10–12), *Microtus hintoni* (13–16) (from Ambrosetti et al., 1979).

insectivores (Fanfani, 2000; Masini et al., 2000, 2005) (Fig. 8A), is included in sediments correlated to the early part of Brunhes chron (Sabato et al., 2005). Other localities, such as Monte Tenda (Verona, Venetia; Bon et al., 1991), have not been revised.

4. Toringian (Fig. 9)

The Early Toringian faunas range from the upper part of middle Galerian to the early part of Post-Galerian. The Early Toringian is well represented in the whole peninsula,

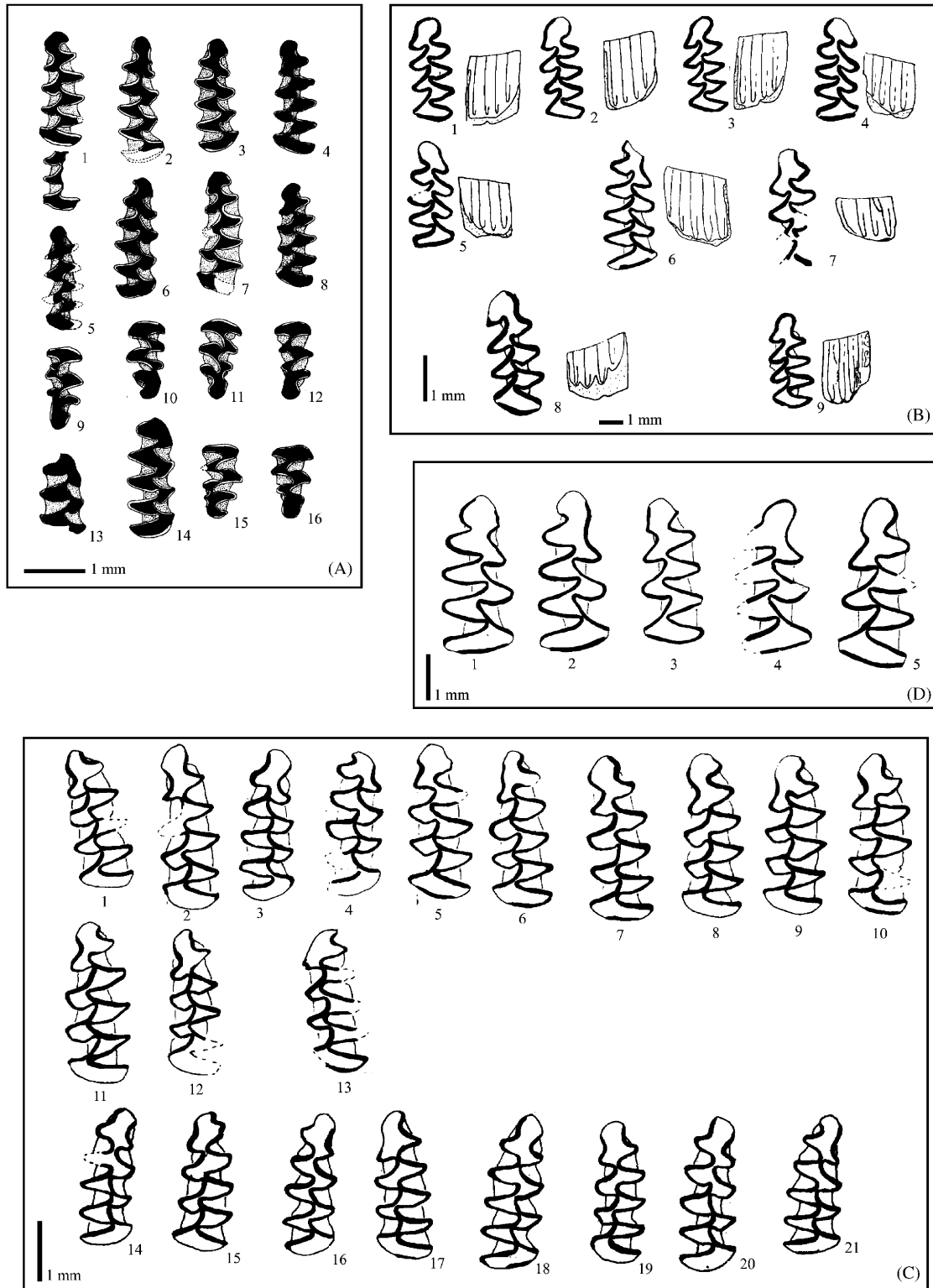


Fig. 8. (A) Rifreddo, San Lorenzo: *Microtus (Terricola) arvalidens* (1–12), *Microtus (Iberomys) huescarensis-brecciensis* (13–15), *Microtus* sp. (16) (from Masini et al., 2005); (B) Isernia La Pineta: *Pliomys episcopalis* (1–5), *Pliomys lenki* (6–8), *Clethrionomys* sp. (9) (from Sala, 1983); (C) Isernia La Pineta: *Microtus* aff. *arvalis* (1, 12), *Microtus brecciensis* (13), *Microtus (Terricola)* sp. (from Sala, 1983); (D) Isernia La Pineta: *Arvicola mosbachensis* (from Sala, 1983).

e.g. Isernia La Pineta (homonimous FU of middle Galerian) (Molise; Sala, 1983, 1996a) (Fig. 8B–D), Visogliano shelter (Cattani et al., 1991; Fanfani, 1998,

2000) (Fig. 10A), Valdemino cave (Sala, 1992; Nocchi and Sala, 1997, 1998), Venosa-Notarchirico (Potenza, Basilicata; Sala, 1999) and Spessa II (Bartolomei, 1964, 1970)



Fig. 9. Toringian Italian sites: 1, Isernia La Pineta; 2, Valdemino, Savona; 3, Venosa-Notarchirico, Potenza; 4, Visogliano and San Giovanni di Duino, Trieste; 5, Fontana Ranuccio, Frosinone; 6, Boscovichianuova, Ghiacciaia cave and Tagliente shelter, Verona; 7, Spessa II, San Vito di Leguzzano, San Bernardino Maggiore, Broion cave, Vicenza; 8, Paglicci cave, Foggia; 9, Scario S.G., Castelcivita cave and Serratura cave, Salerno; 10, San Sidero, Lecce; 11, Ferrovia cave, Ancona.

(Fig. 10B). Among these only Valdemino cave lacks *A. mosbachensis*, but includes *Allocricetus bursae*, *P. episcopalis*, small-sized *Microtus brecciansis*, *Oryctolagus burgii*, etc. Visogliano shelter (lower levels) (Trieste, Julian Venetia; Cattani et al., 1991) is here referred to the late middle Galerian.

A. mosbachensis is relatively frequent at sites of the late Galerian. Among these Fontana Ranuccio (Frosinone, Latium), Boscovichianuova (Verona, Venetia), San Vito di Leguzzano (Vicenza, Venetia) and San Giovanni di Duino (Trieste, Julian Venetia) are particularly noted for their rich faunal content.

The variations in the composition of these Early Toringian faunas indicate the occurrence of marked climatic fluctuations. Taxa such as *Ochotona pusilla* and *Spermophilus citellus* have been recorded for the first time in north-eastern Italy. The evolutionary degree of some taxa (e.g. *Microtus (Iberomys)*) and the occurrence/absence of others (*Pliomys*, some *Microtus* species) allow a finer arrangement in a climato-stratigraphical succession.

The appearance of *A. terrestris*, the marker of the Late Toringian, precedes the Last Interglacial Stage (Eemian) in Italy. This species is, however, affected by a large amount of morphological–geographical variability of the enamel differentiation pattern (Maul et al., 1998; Masini et al., 2003; Paunescu et al., 2004).

The faunas of this mammal zone are very well known in the peninsula, their variability reflecting the strong climatic

fluctuations typical of Marine Isotope Stage (MIS) 6–2. During this period, the biogeographical subdivision increases the diversity in the faunal distribution between the Ligure-Tyrrhenic and Adriatic sides of the Italian peninsula. This pattern is mostly evident during the stadials of the Würmian Stage (Sala, 2003; Sala and Marchetti, 2004).

Examples of Late Toringian sites include: Paglicci outer levels (Foggia, Apulia; Bartolomei, 1980), Scario S.G. (Salerno, Campania; Ronchitelli et al., 1998), San Bernardino Maggiore lower levels (Vicenza, Venetia; Bartolomei, 1960), pre-Eemian, stadial strata; Scario level A (Abbazzi and Masini, 1998), San Sidero 3 (Lecce, Apulia; De Giuli, 1983), Grotta della Ghiacciaia (Verona, Venetia; Sala, 1990) the Early Würmian; Broion cave Q–H levels (Vicenza, Venetia; Zanalda, 1994; Colamussi, 2002), Castelcivita cave (Salerno, Campania; Masini and Abbazzi, 1997), Tagliente shelter Mousterian levels (Verona, Venetia; Bartolomei et al., 1984), Middle Würmian; Tagliente shelter Epigravettian levels (Capuzzi and Sala, 1980), Serratura cave (Salerno, Campania; Bertolini et al., 1996), Grotta della Ferrovia (Ancona, Marche; Bartolomei, 1966) Upper Würmian.

The faunal substitutions are very frequent in stratigraphical sequences and it is difficult to synthesize the succession of events since a very important role is also played by morphology and distribution of the mountain topography (Sala, 1990). In fact, the climatic variations force the autochthonous faunas to move up and down from high to low altitude and then induce the allochthonous species to migrate through the only two passages, in the Ligurian coast to the west and in central Slovenia to the east (Sala, 2003).

5. Discussion and conclusions

The geographical barriers of the Alps and Apennine Mountains chains render the Italian peninsula partially isolated from the rest of Europe. The climatic aspect, however, seems to be more important in controlling the dispersals and the distribution of small mammalian taxa in the peninsula. The scenario is rendered even more complex by the climatic subdivision of Italy: the western Ligurian Tyrrhenian side, with a characteristic Mediterranean climate; the Eastern–Adriatic–Po Valley side, with a more severe and continental-type climate. One should also keep in mind that the narrow peninsular configuration underwent continuous and important variations as regards the distribution and form of landscape, both following the Alpine–Apennine orogeny and the climatic oscillations, the latter particularly well developed and well pronounced in the Middle and Late Pleistocene.

Actually all these factors had only a partial influence on the dispersal of small mammals in Italy. Cosmopolitan species are actually well represented and are associated with taxa having an eastern affinity in different periods and in the various geographical areas (i.e. *Ochotona*, *Sciasta*, *Villanyia*) and from south western provenance, such as

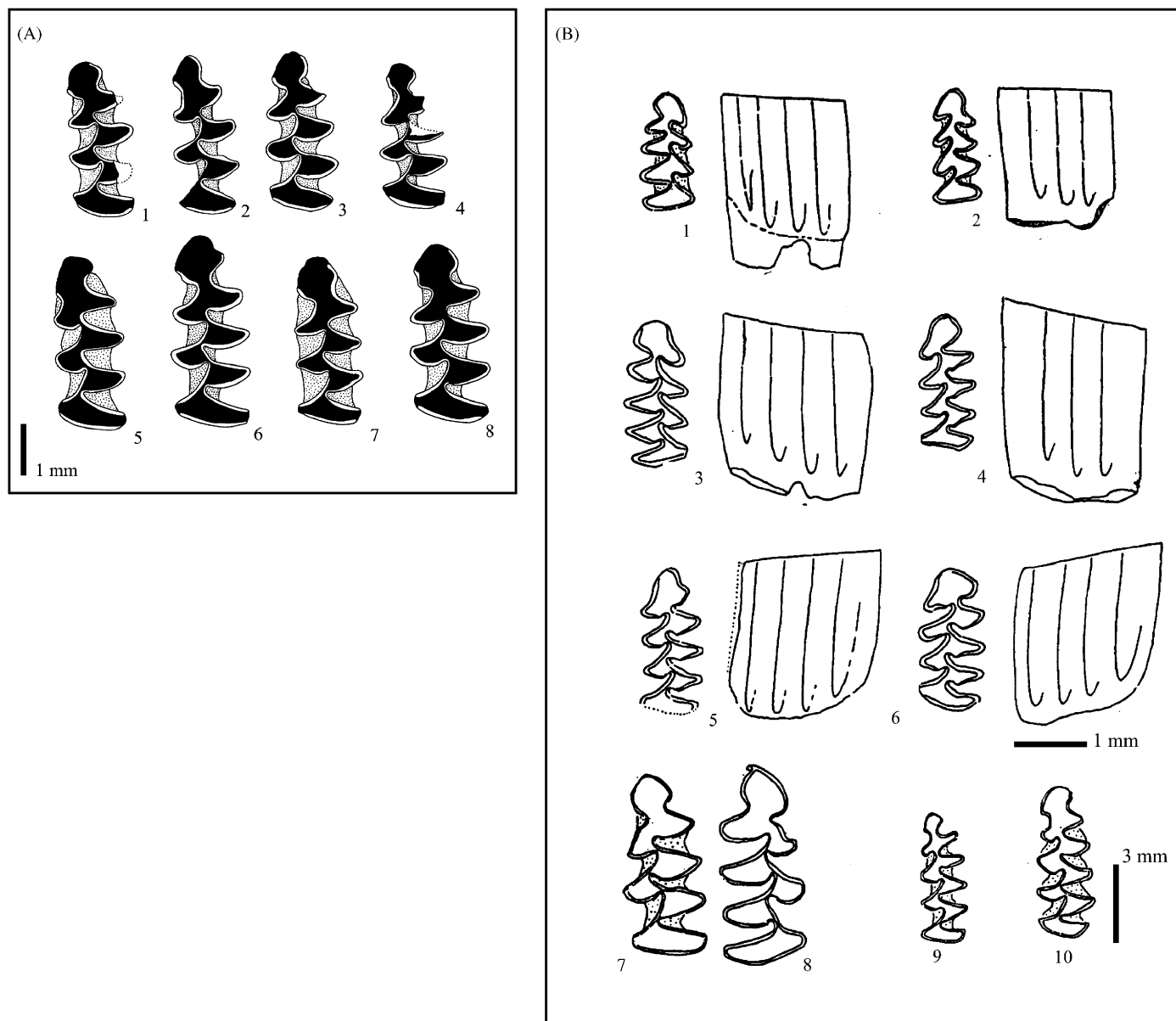


Fig. 10. (A) *Arvicola mosbachensis* from Visogliano (1–4) and *A. terrestris* from Scario (5, 6) and Castelcivita (7, 8) (from Maul et al., 1998); (B) Spessa II: *Clethrionomys* sp. (1, 2), *Pliomys episcopalpis* (3–6), *Arvicola mosbachensis* (7, 8), *Microtus (Terricola)* sp. (9, 10) (from Bartolomei, 1964, 1970).

Microtus (Iberomys) and *Microtus (Allophaiomys) chalinei*. This is an important characteristic since it indicates that the Italian territory was a meeting point for fauna from central eastern European and the western Mediterranean bioprovinces. The Italian fauna succession could therefore be very useful for correlating the succession of faunas from these two distinct biogeographical regions. Furthermore, the possibility of using the sequences of the small, but abundant, Plio-Pleistocene sedimentary basins to calibrate the faunal succession is of great interest for chronostratigraphical correlation.

The compilation of the data concerning the available knowledge for the Plio-Pleistocene, has however, also indicated that some gaps exist in the record. These gaps are important for a critical interpretation of this report.

The *M. hassiacus-stehlini* zone, even though it is represented at a site which is very rich in taxa (Cascina Arondelli) and the following *M. polonicus* zone even more so, are somewhat under-represented in terms of number of sites and taxa. Furthermore the *M. polonicus* zone has a somewhat younger chronological distribution with respect to that reported from other European regions. A second poorly represented zone corresponds to the Late Biharian, which is represented only by two localities that have recently been excavated and for which good stratigraphic control is available: other sites, potentially belonging to the same unit, are still to be revised.

Even with its problems and much work still to be done, the small mammal documentation in Italy is of great

interest for the biogeography and biochronology of Europe.

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