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Article

Moncucco Torinese, a new post-evaporitic Messinian fossiliferous site from Piedmont (NW Italy)

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With 6 figures

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Abstract: The Moncucco Torinese site (Piedmont, NW Italy) bears very diverse and abundant fossil assemblages with ostracods, brackish to freshwater and terrestrial molluscs, fishes, amphibians, reptiles, birds and mammals. The Moncucco section records the shift from shallow brackish waters ("Lago-Mare" facies) to freshwater/emerged environments. The analysis of the fossil assemblages evidences the presence of elements with different taphonomical histories. However, their age difference is minimal as the taphonomically reworked brackish water molluscs of the upper layers of the section come from the "Lago-Mare" sediments of the basal layer. According to stratigraphical and palaeontological context the age of the Moncucco fossil assemblages is post-evaporitic Messinian. Moncucco is one of the rare Italian non-marine fossil assemblages of this age comprising vertebrate and invertebrate taxa. The small mammals from Moncucco indicate that in this period NW Italy was a cross-road for immigration in the Italian peninsula, as testified by the presence of taxa of different origin (eastern Europe: *Prolagus sorbinii* and *Hansdebruijnia* sp.; western Europe: if the presence of genus *Huerzelerimys* will be confirmed) together with species known only from the Italian peninsula as *Centralomys* cf. *C. benericettii.*

Key words: ostracods, molluscs, vertebrates, taphonomy, systematics, biochronology, palaeobiogeography, post-evaporitic Messinian, NW Italy.

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1. Introduction

The aim of this paper is to discuss the first results of an ongoing research on the mollusc and vertebrate fossil assemblages from the Piedmont Messinian continental deposits by Torino researchers. At present, the researches are focused on the locality of Moncucco Torinese (Asti), shortly reported at the time of its discovery (GIUNTELLI et al. 2007), where the mainly pelitic lithosomes of the "facies a *Congeria*" crop out (Fig. 1). These studies are carried on in the framework of researches on the latest Miocene (6.1 to 5.3 Ma) sedimentary units referred to the complex geodynamic events of the Messinian Salinity Crisis (DELA PIERRE et al. 2007 and references therein, CLARI et al. 2008).

The continental deposits overlying the evaporitic Vena del Gesso Fm. are quite widespread within the Tertiary Piedmont Basin in southern Piedmont (DELA PIERRE et al. 2007). However, fossil vertebrate records are presently limited to those of Ciabòt Cagna (CAVALLO et al. 1993) and the recently discovered Ver-

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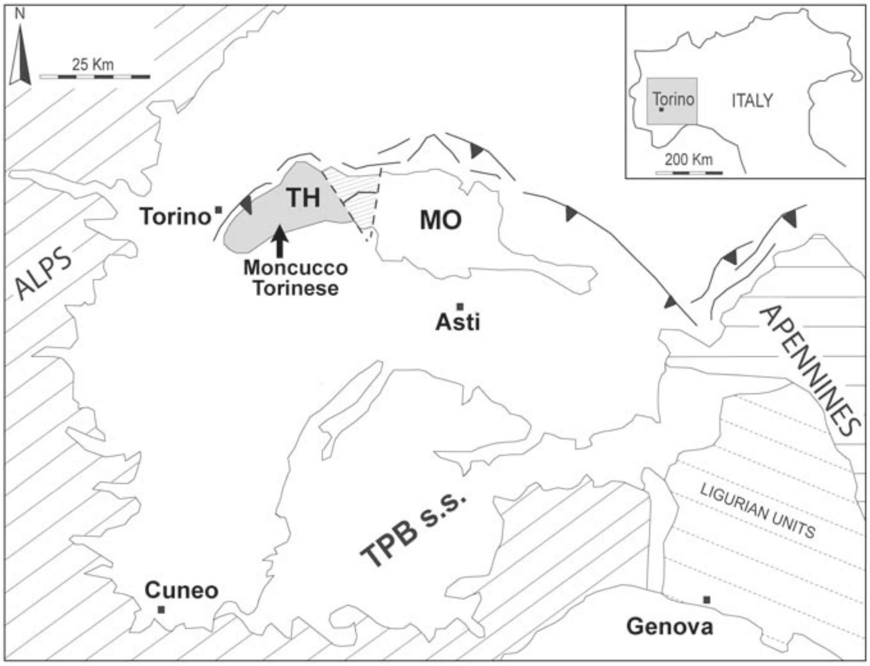

Fig. 1. Structural sketch map of NW Italy (modified after Zunino & Pavia 2009) and location of the Moncucco Torinese fossiliferous locality. TH: Torino Hill; MO: western Monferrato; TPB: Tertiary Piedmont Basin.

duno (Pavia et al. 2009; Sardella 2008) in the Alba area, currently under study. The description of new mammal assemblages of this age has a primary importance for both palaeobiological and palaeobiogeographical purposes (Rook et al. 2006): first, Messinian vertebrate localities are quite rare in peninsular Italy (Rook et al. 2005, 2008 and references therein); second, during the Late Miocene NW Italy constituted a faunal dispersion pathway starting from European countries towards the central Mediterranean areas. The study of the Piedmont material could thus represent a fundamental step in the knowledge of the latest Miocene Italian and south-European mammal faunas. In this framework, the study of the palaeovertebrate site of Moncucco Torinese deserves particular attention.

2. Moncucco Torinese: geological setting and lithostratigraphy

The Moncucco gypsum quarry was first described by Sturani (1976) as a reference site for the studies on the evaporitic Messinian in Piedmont. More recently, it has been used to describe the upper Miocene evolutionary sequence of the Tertiary Piedmont Basin (Irace 2004) and represents a reference for the genetic processes of chaotic sedimentary complexes (Dela Pierre et al. 2007).

The lithostratigraphic succession cropping out in the quarry is quite complex due to the interaction of syn- and post-depositional tectonic episodes, connected with diapiric and melange processes (Dela Pierre et al. 2007), so that any schematisation is hardly traceable. For our purpose, it is sufficient to mention the sedimentary units which comprise the fossiliferous layers (op. cit., Trenkwalder et al. 2008).

The youngest marine Miocene terms observable in the Moncucco quarry are the hemipelagic marls and laminated mudstones of the topmost Marne di Sant'Agata Fm., pre-evaporitic early Messinian in age. These sediments are unconformably overlaid by the evaporitic Messinian Vena del Gesso Fm. (formerly Formazione Gessoso-Solfifera; Roveri et al. 2008 and references therein) composed of a 80 m thick selenitic gypsum unit. The exploited gypsum mass is followed by the post-evaporitic "Valle Versa Chaotic Complex" (Dela Pierre et al. 2007) unconformably overlaid by the brackish-water to continental deposits of the "facies a *Congeria*", that represent

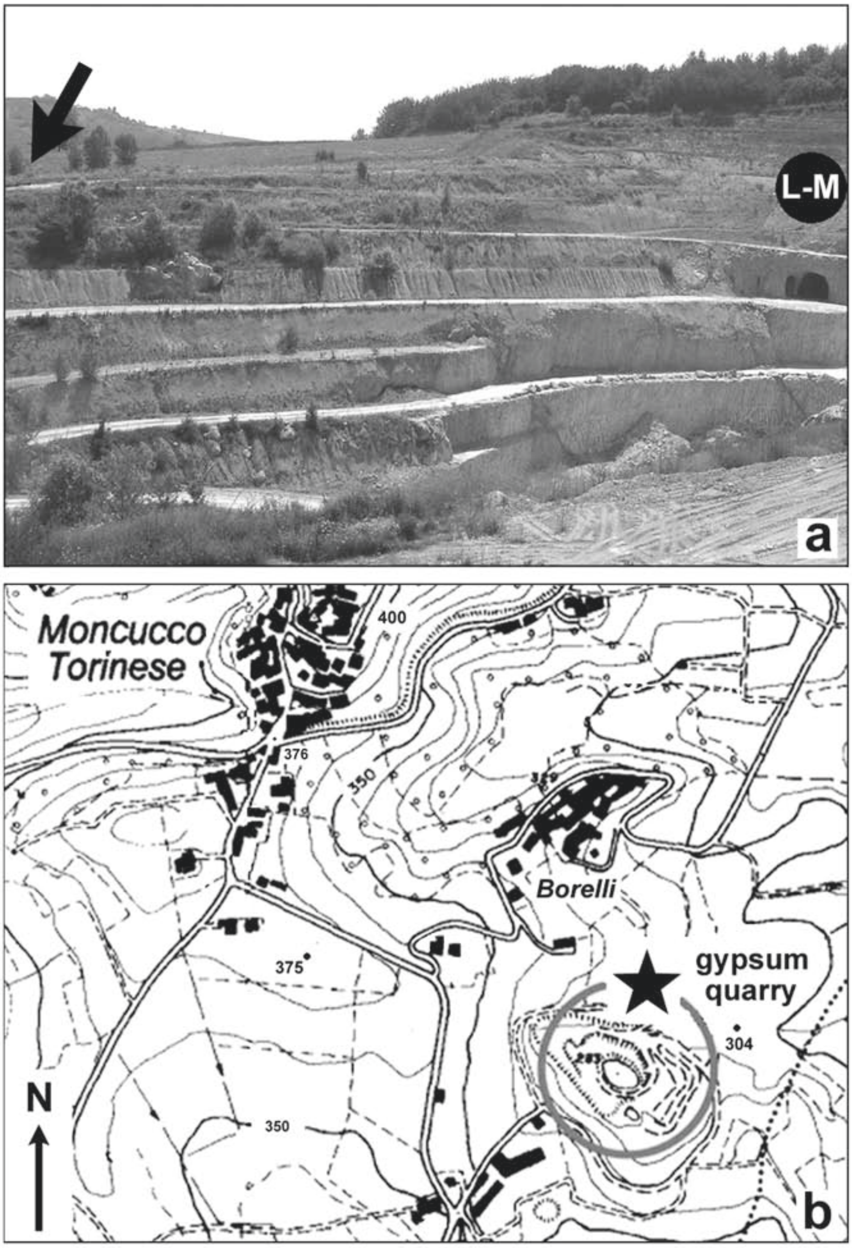

Fig. 2. a – Southern sector of the gypsum quarry of Moncucco Torinese: outcrop of the "Lago-Mare" deposits (L-M) and position of fossiliferous section (arrow); **b** – Topographic sketch of the Moncucco Torinese quarry and location of the fossiliferous locality (star).

the lateral equivalent of the Conglomerati di Cassano Spinola Fm. (Clari et al. 2008) and are correlatable to the upper Messinian "Lago-Mare" sediments of the Mediterranean region (see also Abbazzi et al. 2008). The last term of the Moncucco succession is represented by the deep-water Argille Azzurre Fm. which micropalaeontological content refers to the MP11 and MNN12 biozones of the Zanclean (Trenkwalder et al. 2008). In the central sector of the quarry, the "facies a *Congeria*" is nearly 6 m thick (Irace 2004);

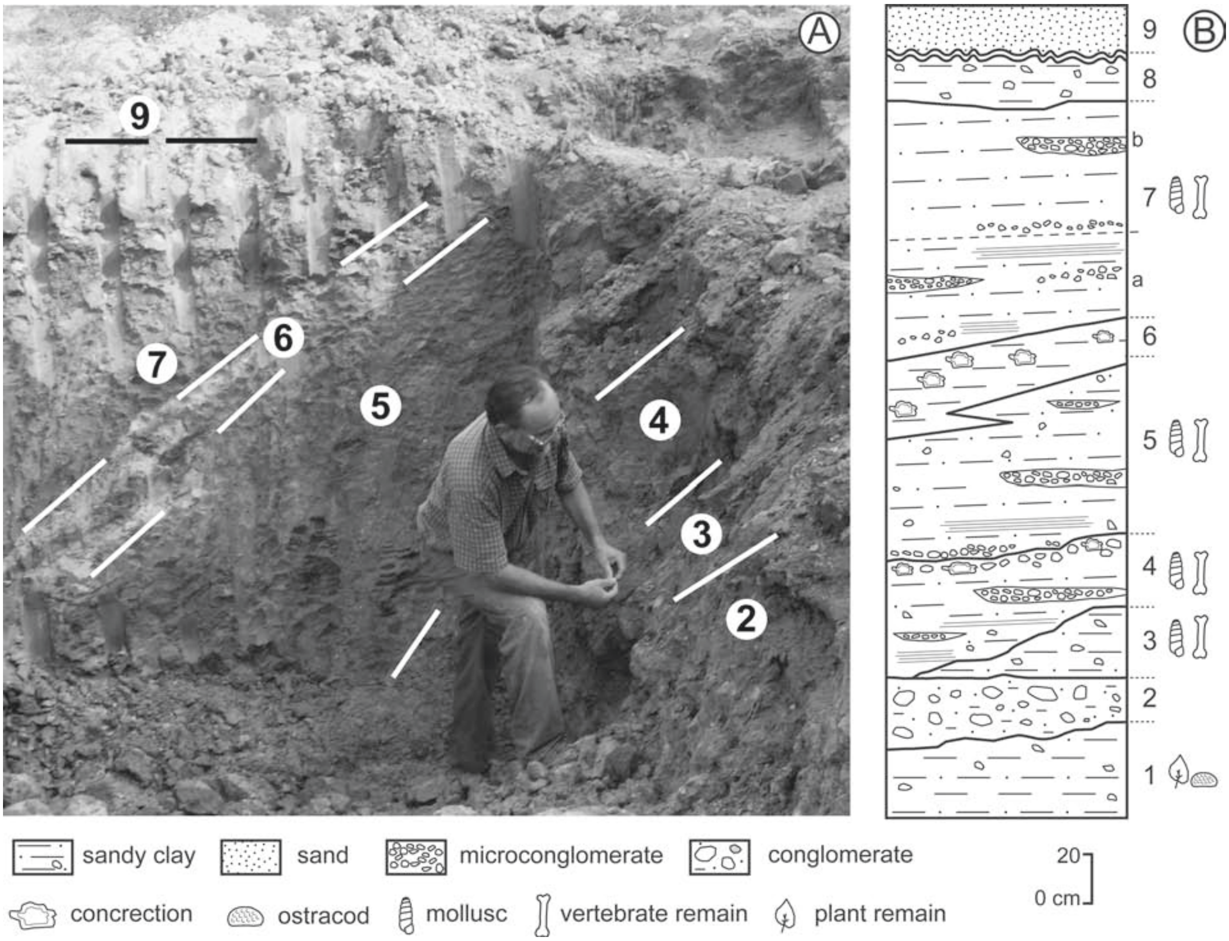

Fig. 3. The "facies a *Congeria*" in the northern corner of the Moncucco Torinese quarry: section after digging with P. Giuntelli as a scale (A) and stratigraphical column of the succession (B).

most of this unit is composed of beige to green-blue clayey marls with calcareous palaeosoil interbeds, scattered root traces and firm ground burrows filled up by the matrix of the black arenitic bed that closes the continental sequence. The "facies a *Congeria*" yielded significant brackish-water molluscs and a rich fresh- to brackish-water ostracod assemblage which indicates a latest Messinian age, near the Miocene-Pliocene boundary.

In the southeastern part of the quarry, within the clayey-marl interval, P. Giuntelli and G. Pavia in 2006 located some thin detritic horizons that yielded frequent brackish- and freshwater molluscs, and small mammal bones (Fig. 2). Large surveys were then planned in this still unexcavated sector of the quarry, where the increased thickness of the "facies a *Congeria*" beds would implement the fossil record. The superficial diggings were authorized by the Soprintendenza per i Beni Archeologici di Torino (auth. 6884, September, 21st 2007). Field works developed during the whole 2008 and consisted in repeated samplings of the fossiliferous beds and in a manual dig deep enough to reach a level that could be correlatable with the succession described in the central quarry.

The outcrop exposed more than 3 m of mainly sand-clayey marls, some 40° south-dipping. Nine depositional units were distinguished, all being separated by erosional discontinuities (Fig. 3). The palaeontological sampling was complicated by lateral variations in thickness and the incidence of several compressional small faults. From the bottom the nine units are:

1. (about 0.40 m from the bottom of the excavation). Yellowish sandy clays intercalated by greyish clays

with scattered pebbles. The fossil assemblage is composed of plant debris, brackish-water ostracods and reworked planktic forams. This facies corresponds to the one described by TRENKWALDER et al. (2008) at the base of the "Lago-Mare" facies in the central quarry section except for the absence of molluscs.

2. (0.20-0.40 m) Polygenic, matrix-supported conglomerate whose cm- to dm-sized pebbles consist of calcareous concretions, sandstones, marly limestones, ophiolites; the matrix is clayey-sandy and pebbles do not show any imbrication texture. No fossils were found. The lower boundary of the layer corresponds to an erosional surface deeply cut onto layer 1.

3. (0-0.30 m) Slightly sandy clays with scattered, cm-sized pebbles of the same type of layer 2. The layer closes towards the northern sector due to deep erosion. Fossil are frequent and consist of molluscs and small-sized vertebrate remains: such content is common also in overlying layers. Vertebrate fossils of small and middle size are randomly present. Molluscs are represented by both autochthonous terrestrial and freshwater taxa, and reworked brackish specimens (see section 5 "Taphonomy" for details).

4. (0.30-0.50 m) Dark brown to blackish sandy clays with prevailing calcareous grains and scattered concretions, sometimes lined-up in discontinuous horizons. The thickness increases towards the northern sector due to sediment accommodation into the erosional depression upon layer 3. Laminated texture is frequent and alternates with microconglomeratic lenses. A topmost thicker, clast-supported conglomerate is composed of polygenic pebbles and large calcareous concretions, sometimes up to 40 cm thick. Two large palaeontological samples have been collected: the first one from the basal, more granular horizon, the second from the topmost conglomerate.

5. (0.50-0.75 m) Texture and lithologic characters are quite similar to those of layer 4, the two layers being separated by a sharp erosional surface and by the more granular horizon at the very base of layer 5. Also in this case, two exhaustive palaeontological samplings have been organized, at the base and in the middle part of the layer where laminated texture is absent. Fossils are frequent, and consist of molluscs and small-sized vertebrate remains.

6. (0.20-0.30 m) Grey-whitish clayey horizon with high carbonate content that produces local concretions. No fossils were found.

7. (max. 1.10 m) The layer could be separated in two parts (7a, b in Fig. 3) though their boundary cannot be precisely defined. The lower one is composed of frequently laminated, dark brown to dark grey sandy clays with small calcareous pebbles organized in more or less continuous horizons. The upper part of the layer consists of greenish, homogenized sandy clays. Fossils (molluscs and small vertebrates) are frequent and were sampled in the microconglomeratic horizons present in both sublayers.

8. (max. 0.20 m) Conglomeratic clays with scattered, rounded pebbles. No fossils were found.

9. (max. 0.15 m) A sub-horizontal, mostly lenticular bed of yellowish sands covers the "facies a *Congeria*" succession. Its lower boundary is unclear because of the debris and colluvial cover. Though the outcrop is very small, this bed seems to be correlatable with the Upper Pleistocene fluvial deposits described by ALESSIO et al. (1982) and referred to the ancient downflow of the Po River south of the Torino Hill.

3. Material and methods

Approximately two tons of clayey material from the Moncucco Torinese section have been washed and sieved. The microvertebrate material is here analyzed without distinctions between different levels. Molluscs and ostracods are discussed following the succession of layers.

All the analyzed specimens are housed in the Museo di Geologia e Paleontologia of the Torino University and there inventoried following the indication of PAVIA & PAVIA (2004) with the acronym PU.

4. Systematic palaeontology

4.1. Ostracoda

Analysis of a sample collected from layer 1 evidenced the presence of an ostracod assemblage referrable to brackish environments (*Amnicythere propinqua, Cyprideis agrigentina, Loxoconcha kochi*) with Paratethyan affinities. From a biostratigraphic point of view, the recognised ostracod assemblage pertains to the *Loxocorniculina djafarovi* Zone, as defined by CARBONNEL (1978), that characterizes the upper Messinian post-evaporitic deposits of the whole Mediterranean area.

According to the ostracod content, layer 1 of the Moncucco succession was deposited in brackish

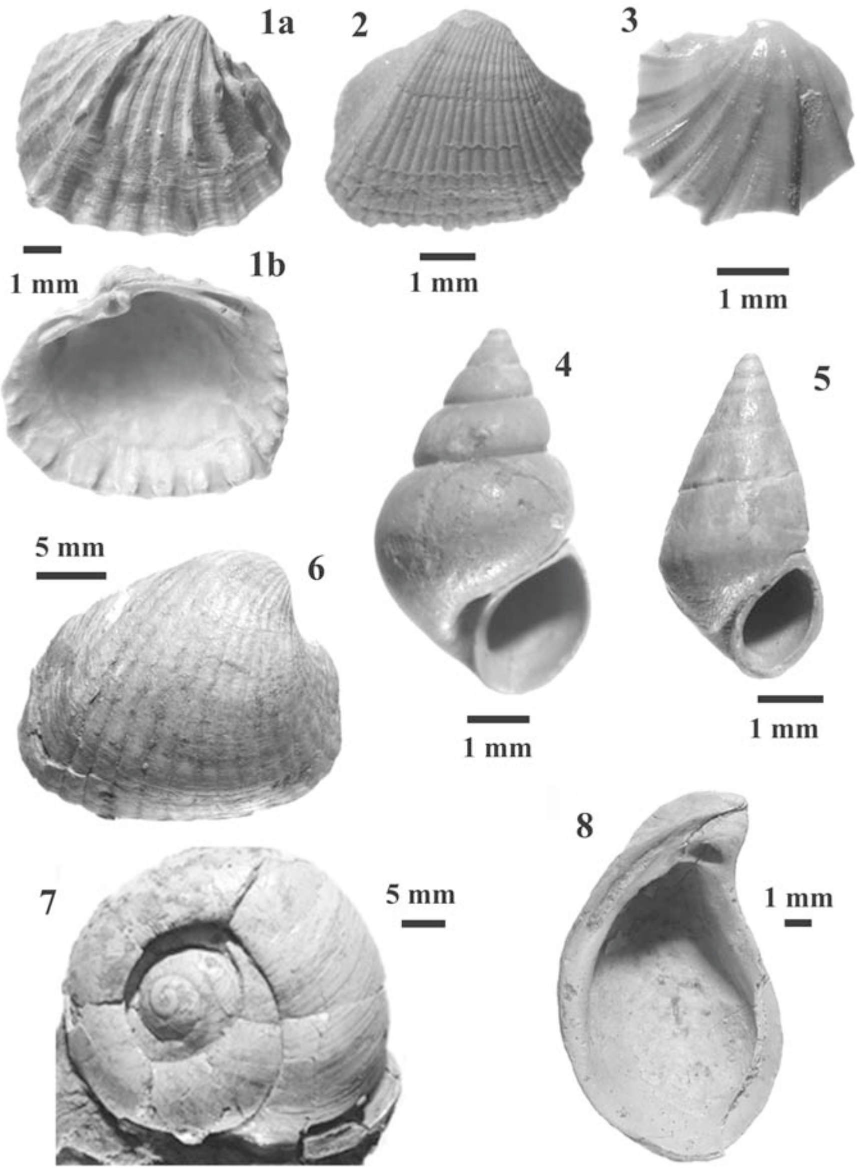

Fig. 4. Molluscs from Moncucco Torinese. **1** – *Pontalmyra partschi*, valve dx, PU127024 (a) external view, (b) internal view. **2** – *Pontalmyra* sp., valve dx, PU127025. **3** – *Euxinicardium subodessae*, valve sin, PU127026. **4** – *Saccoia fontannesi*, PU127027. **5** – *Saccoia oryza*, PU125028. **6** – *Prosodacnomya* cf. *P. sturi sabbae*, PU127029. **7** – *Eobania* sp., PU127031. **8** – *Dreissena* ex gr. *D. rostriformis*, valve sin, PU127030.

waters corresponding to the post-evaporitic "Lago-Mare" episode. The most precise indicator is *Amnicythere propinqua* which is typical of shallow (10-12 m), oligo-mesohaline (4-13,25‰) waters (Gliozzi & Grossi 2004); very shallow waters are also indicated by the euryhaline (0,7-150‰) genus *Cyprideis*. The euhaline *Loxoconcha kochi* (5-40‰) fits these salinity parameters (Neale 1988; Gross 2002).

4.2. Mollusca

Fossil mollusc assemblages from Moncucco mainly consist of non-marine taxa, except for fragments of marine taxa clearly reworked from the Marne di Sant'Agata Fm. The brackish-water molluscs are relatively common in levels 3 to 5 and 7, with a peak of abundance at the base of level 4. Terrestrial and freshwater taxa are less numerous; their abundance is higher (even if discontinuous) in level 7.

The taxonomic attribution of fossil molluscs is often uncertain due to the poor preservation state of hinge and cardinal processes of pelecypods (e.g.: in Lymnocardiinae) and to the lack of updated literature on the subject of Piedmont Neogene terrestrial and freshwater taxa, the publications by Sacco (1886, 1887, 1895, 1896, 1898), partly revised by Esu & Ciangherotti (2004) being the only available references.

Oligo/mesohaline assemblages consist of gastropods and pelecypods of the following families: Neritidae: *Theodoxus mutinensis*; Melanopsidae: *Melanopsis narzolina*; Thiaridae: *Melanoides curvicosta*; Hydrobiidae: *Saccoia fontannesi* (Fig. 4.4), *S. oryza* (Fig. 4.5); Dreissenidae: *Dreissena* ex gr. *D. rostriformis* (Fig. 4.8). Lymnocardiinae (Fam. Cardiidae) are the most abundant, and consist of several species, currently under study. For the moment, we can mention *Pontalmyra partschi* (Fig. 4.1a, b), *Pontalmyra* sp. (Fig. 4.2), *Euxinicardium subodessae* (Fig. 4.3), *Prosodacnomya* cf. *P. sturi sabbae* (Fig. 4.6).

Freshwater molluscs are represented by prosobranch and pulmonate gastropods, such as Valvatidae, Physidae and Planorbidae; freshwater pelecypods are present with only few specimens of Sphaeriidae, all found in level 7.

The terrestrial molluscs are more diverse, with taxa belonging to prosobranchs and pulmonates of the families Cochlostomatidae, Aciculidae, Ellobiidae, Pyramidulidae, Vertiginidae, Chondrinidae, Pupillidae, Valloniidae, Discidae, Gastrodontidae, Limacidae, Parmacellidae, Ferussaciidae, Clausiliidae, Hygromiidae, Helicidae.

On the basis of the mollusc taxa (analyses of both allochthonous and autochthonous assemblages, excluding the taphonomically reworked brackish-water molluscs) the most detailed palaeoecological setting can be obtained from level 7. Actually, the presence of taxa that tolerate ipohaline waters, as Physidae, Sphaeriidae, and terrestrial forms as Aciculidae, Pyramidulidae, Clausiliidae, Limacidae, indicate a freshwater environment with neighbouring woody areas subject to frequent and heavy rainfalls.

4.3. Vertebrates

Fishes. – Several remains of Chondrichthyes and Actinopterygii Teleostei have been recovered. The most abundant and diversified specimens are Chondrichthyes teeth; they are mainly of small dimensions, attesting to the presence of both young individuals and small taxa. A preliminary survey refers these shark teeth to forms pertaining to the bathial zone (W. Landini, pers. com.). Thus, as the marine molluscs, they must be classified as taphonomically reworked fossils pertaining to the Marne di S. Agata Fm.

Amphibians and Reptiles. – Amphibia and Reptilia remains are abundant. They mainly consist of vertebrae of amphibians, lizards and snakes, and cranial fragments of lizards.

Birds. – Bird remains are quite rare in the whole assemblage. The study of the recognizable bird bones recovered up to now allows to recognize the presence of six taxa. A complete left carpometacarpus can be attributed to *Palaeortyx* sp. (Fig. 5.6), a Phasianidae genus commonly reported from Miocene assemblages. The morphological characteristics of the bone fit better with *Palaeortyx* than with other Phasianidae, but the dimension of the fossil remain is smaller than that of *Palaeortyx phasianoides* and larger than *P. brevipes* and *P. volans* (Göhlich & Mourer-Chauviré 2005; Göhlich & Pavia 2008), the only species of this genus of which the carpometacarpus has been found and described. A single coracoid fragment can be attributed to *Columba* sp., while a distal tibiotarsus and some pedal phalanges indicate the presence of a small Strigidae. A single pedal phalanx also indicates the presence of a middle-sized Strigiformes and some more or less fragmented bones reveal the presence of at least two species of Passeriformes.

Mammals. – The Moncucco vertebrate assemblage is dominated by mammals. Small mammal remains are particularly common and diversified whereas large mammals are represented by scattered/rare specimens. The analysis of the large mammal remains reveals the presence of at least seven taxa. A single left astragalus (Fig. 5.1a, b) has been as attributed to the Colobinae monkey *Mesopithecus* sp. (Rook 1999). Some upper and lower teeth have been identified as *Stephanorhinus* sp. (Fig. 5.7) and *Tapirus* sp. (Fig. 5.2a, b). The Arctiodactyla remains are more numerous and attest to the presence of at least four taxa: a fragmented right hemimandible (Fig. 5.3a, b) can be attributed to a

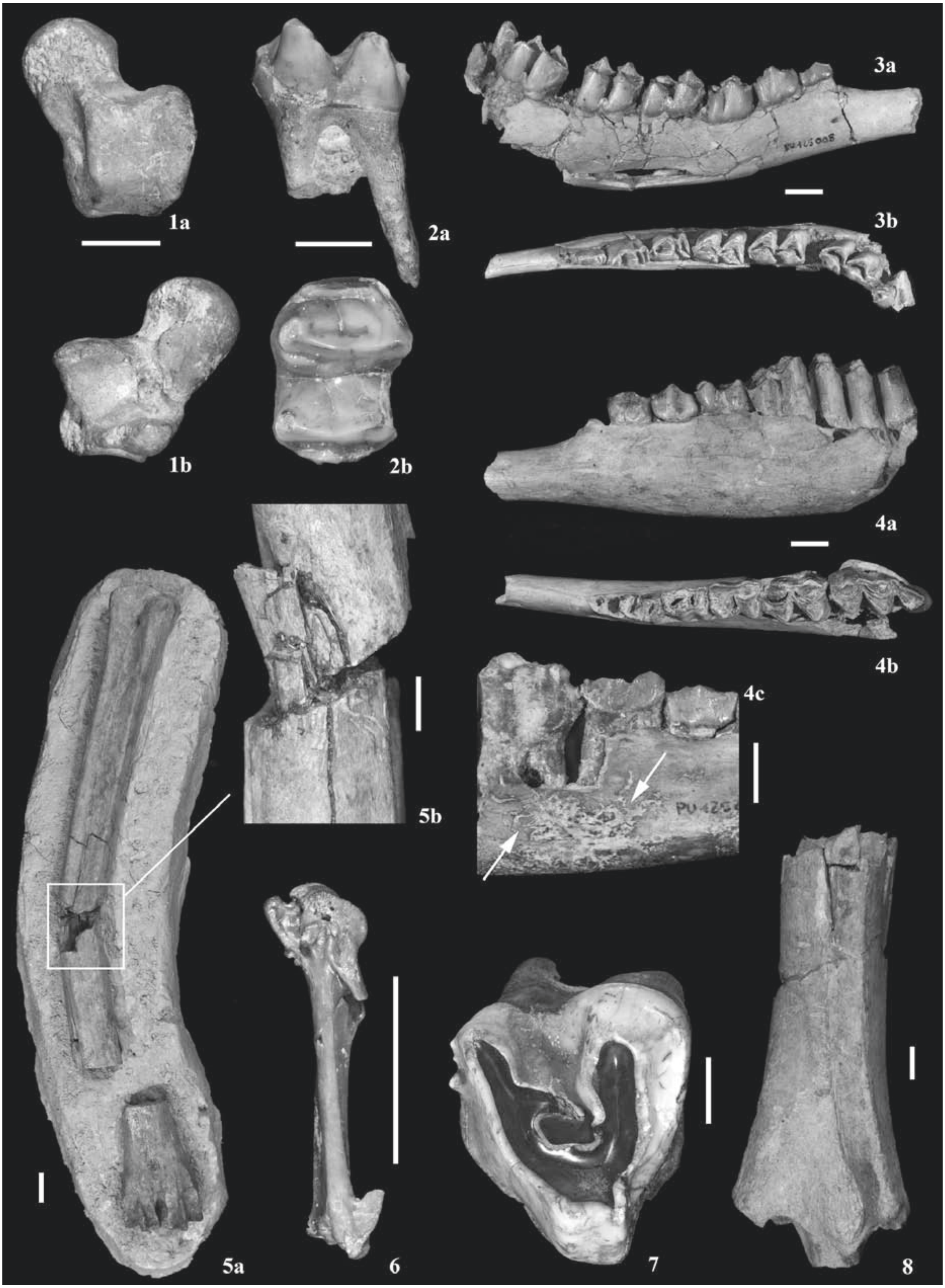

Fig. 5 (Legend see p. 97)

small-sized cervid; a left hemimandible (Fig. 5.4a, b, c), a right metatarsus (Fig. 5.5a, b) and two left scapho-cuboids can be attributed to a middle-sized antelope; a single horn fragment and a first phalanx belong to a small-sized bovid; a distal tibia has to be referred to a large-sized bovid (Fig. 5.8). The large mammal taxa found at Moncucco are on the whole comparable to those described from other Italian Messinian localities (Rook et al. 1999).

Erinaceomorpha: Hedgehogs are poorly represented. Apart from two incisors, a d3 and a premolar, which yield no useful taxonomic characters, a P3 and a m3 have been found (Fig. 6.1-6.2). These clearly belong to a galericine. In the European Turolian, two genera have been recognised, *Parasorex* and *Schizogalerix* (Van den Hoek Ostende 2001, but note that Ziegler (2005) places all Late Miocene Galericinae in *Schizogalerix*). Both genera have a hypocone on the P3, which agrees with the specimen from Moncucco. On the basis of the material now available, the Moncucco gymnure cannot be identified to the genus level.

Soricomorpha: Mole fossils are represented by a premolar and a m3 (Fig. 6.3-6.4). The premolar is a unicuspid with a very sharp crest. The m3 features a high and sharp trigonid, and a reduced talonid in which the oblique cristid ends close to the metaconid. In morphology, both elements resemble *Talpa*. The taxonomy of the fossil representatives of this genus is in mayhem, as was noted by Doukas et al. (1995) in the description of '*Talpa fossilis*' from the Greek locality of Maramena, and the scanty material available from Moncucco does not allow any speculations about a species designation.

Shrews are by far the most abundant among the insectivores. Unfortunately, they are represented mostly by isolated material, which hampers identification, as Soricidae are notoriously conservative in their molar morphology. Nevertheless, most of the material can be confidently attributed to *Asoriculus gibberodon* (Fig. 6.5-6.7). Two of the three lower incisors are short and bicuspulate, a faint original pigmentation has been preserved in many specimens, the labial cingulum of the lower molars is well developed, a mandible fragment shows the position of the foramen mentale underneath the posterior part of the m1, and the only preserved m3 has a talonid basin. In all of these characteristics the specimens agree with the emended diagnosis for *Episoriculus* [= *Asoriculus*] *gibberodon* in Reumer (1984). Metrically, the Moncucco material fall in the size range of the Hungarian Plio/Pleistocene localities studied by Reumer (1984), but also in that of the assemblage from Maramena (Greece, MN13: Doukas et al. 1995).

Apart from *Asoriculus gibberodon* a second shrew seems to be present in the material (Fig. 6.8). The third lower incisor found, though damaged, is clearly longer and faintly bicuspulate to acuspulate. Some of the lower molars have a more slender aspect than those of *Asoriculus* (although they somewhat surprisingly fall in the same size range), as does one of the M2. This material is insufficient for even a generic identification.

Lagomorpha: Two species of lagomorphs are present at Moncucco. The smallest one is an ochotonid of the genus *Prolagus*. Its tooth size falls within the range of the Messinian-Pliocene species *P. sorbinii* (central-western Italy and NE Greece: Angelone 2007 and references therein; Abbazzi et al. 2008) and *P. michauxi* (central-western Europe: López Martínez 1989; Angelone 2007). The morphological features of *Prolagus* from Moncucco (p3 with triangular anteroconid, triangular/quadrangular metaconid, variable crochet, V-shaped mesoflexus, no enamel hiatus on the thick entoconid, P3 with right-angled connection between lagicone and lagiloph, upper molars with fossettes) allow to ascribe it to *P. sorbinii* (Fig. 6.9).

The other lagomorph present at Moncucco is a leporid represented by a fragment of a juvenile P2 (Fig. 6.10). Two leporid genera are present in the MN13 of central Europe and in particular in the MN13 of Italy: *Trischizolagus* (Rook & Delfino 2003; Abbazzi et al. 2008) and *Alilepus* (Angelone & Rook under review). The size of P2 is similar in the two genera and the main morphological difference is

Fig. 5. Bird and large mammals from Moncucco Torinese. **1** – *Mesopithecus* sp., astragalus sin, PU127000: (a) dorsal view, (b) plantar view. **2** – *Tapirus* sp., m2 sin, PU127001: (a) labial view, (b) occlusal view. **3** – Cervidae indet., mandible dx, PU127008: (a) labial view, (b) occlusal view. **4** – Bovidae indet., mandible sin, PU127007: (a) labial view, (b), occlusal view, (c) detail of lingual side with root marks. **5** – Bovidae indet., metatarsus dx, PU127010: (a) plantar view, (b) detail of the central fracture. **6** – *Palaeortyx* sp., carpometacarpus sin, PU127032. **7** – *Stephanorhinus* sp., M3 sin in occlusal view, PU127004. **8** – Bovidae indet, tibia sin distal end, PU127009.

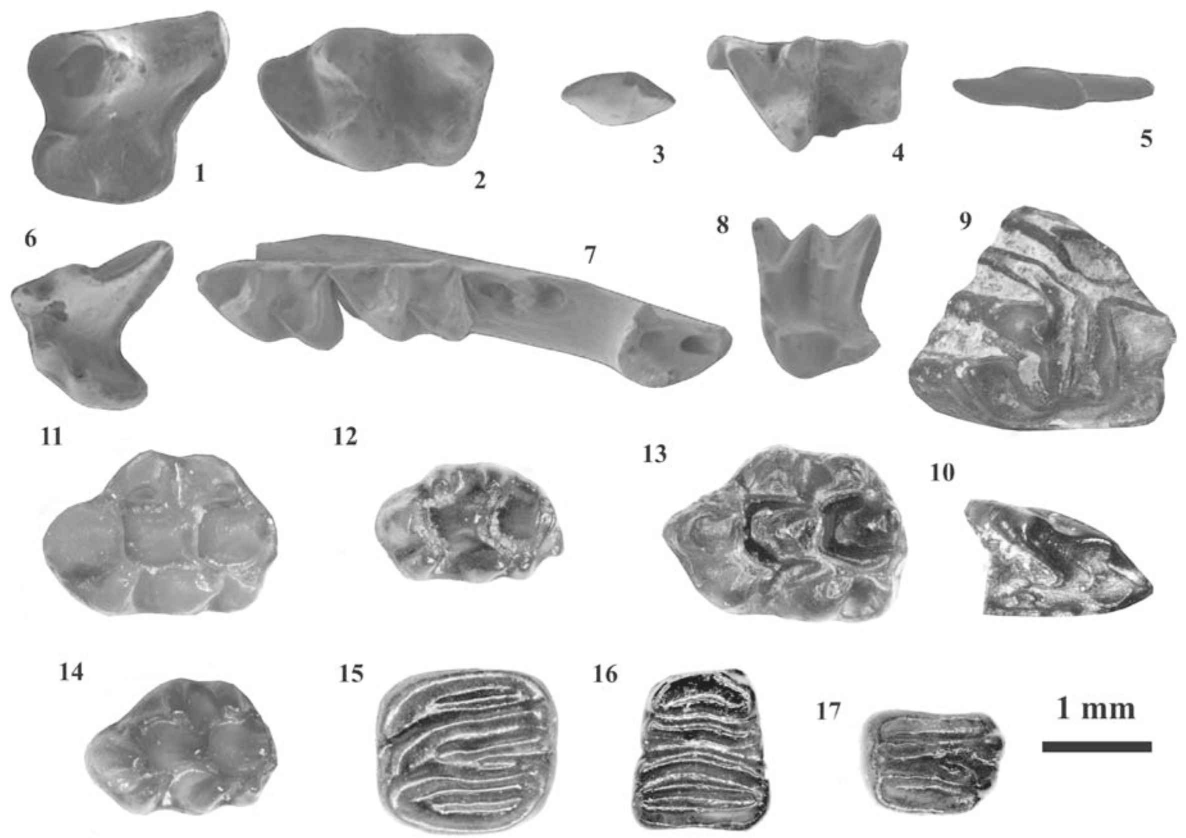

Fig. 6. Small mammals from Moncucco Torinese. **1-2** – *Parasorex* sp. or *Schizogalerix* sp.: (1) P3 sin (L x W: 1.99 x 1.98 mm), PU127033; (2) m3 dx (L x W: 2.38 x 1.50 mm), PU127034. **3-4** – *Talpa* sp.: (3) lower premolar dx (L x W: 1.05 x 0.51 mm), PU127035; (4) m3 sin (L x W: 1.80 x 1.08 mm), PU127036. **5-7** – *Asoriculus gibberodon*: (5) i1 sin (L: 2.83 mm), PU127037; (6) P4 dx (P x BL x LL x W: 0.77 x 1.50 x 0.92 x 1.48 mm), PU127038; (7): mandible dx with m1-2 (L x TRW x TAW: 1.51 x 0.83 x 0.93 mm for m1; 1.39 x 0.81 x 0.85 mm for m2), PU127039**8** – Soricidae gen. et sp. indet., M2 sin (P x BL x LL x AW x PW: 0.87 x 1.14 x 1.06 x 1.46 x 1.35 mm), PU127040. **9** – *Prolagus sorbinii*, p3 sin (L x W: ~1.91 x 2.10 mm), PU127041. **10** – Leporidae indet., P2 sin (L: 0.95 mm), PU127042. **11** – aff. *Huerzelerimys* sp., M1 sin (L x W: 2.18 x 1.53 mm), PU127043. **12** – *Centralomys* cf. *C. benericettii*, M1 dx (L x W: 1.74 x 1.14 mm), PU127044. **13** – *Hansdebruijnia* sp., M1 sin (L x W: 2.29 x 1.67 mm), PU127045. **14** – *Apodemus* cf. *A. etruscus*, M1 sin (L x W: 1.82 x 1.27 mm), PU127046. **15** – *Glis minor*, M1-2 sin (L x W: 1.55 x 1.70 mm), PU127047. **16** – *Muscardinus* cf. *M. vireti*, m1 dx (L x W: 1.52 x 1.31 mm), PU127048. **17** – *Eliomys* cf. *E. truci*, M3 dx (L x W: 0.97 x 1.37 mm), PU127049. Insectivores and rodents have been figured as left specimens; specimens 3, 5, 6, 12, 16, 17 have been mirrored.

the presence of a hypoflexus in *Trischizolagus*. However, the lingual part of the only available tooth from Moncucco is broken. Thus, it is preferable not to venture a classification beyond the family level and classify the larger lagomorph from Moncucco as Leporidae indet.

Rodentia: Within the assemblage, four murid genera can be recognised. The smaller murid present at Moncucco shows an intermediate degree of stephanodonty. A quite similar taxon was first described by De Giuli (1989) from Brisighella as *Castillomys* (*Centralomys*) *benericettii*. Later on, Martín Suárez & Mein (1991) attributed to *Centralomys* a generic rank. M1 from Moncucco show a wide valley between t3 and t6, t3 isolated from t5 and t6; t4, t5, t6 and t9 show a similar size. The labial cingulum is ridge-shaped and not well developed. c1 is present and quite developed as well as the posterior cingulum. The only M2 with preserved roots shows the presence of four roots. De Giuli (1989) mentions a large t1 bis, present but small in our material and a sporadic presence of tma in m1, always present in our material. M1 length (avg. 1.73) perfectly fits with that of *Centralomys benericettii* from Brisighella (avg. 1.76: Martín Suárez & Mein 1991). Up to now *C. benericettii* is known only from Italian mainland (Brisighella, post-evaporitic Messinian; Borro Strolla, latest Pliocene, Tuscany: Abbazzi et al., 2008), whereas *Centralomys* sp. has been reported from Ariano Irpino (Kotsakis et al. 2003). For the moment, we attribute the Moncucco specimens to *Centralomys* cf. *C. benericettii.*

The second murine species seems to be a species of the genus *Hansdebruijnia*. Initially described as a subgenus of *Occitanomys* by Storch & Dahlmann (1995), it has been recently elevated to a generic rank (Storch & Ni 2002). Our specimens are larger than *H. neutrum* and smaller than *Occitanomys montheleni* (Aguilar et al. 1986) and than other species of the subgenus *Rhodomys* (Martín Suárez & Mein 1991). t1 is either adjacent to t5 or connected to it by a short ridge. t3 is connected to t5 in three of our six specimens. t4 may be either adjacent or connected to t8 by a low ridge. In m1 the tma is well defined (it is absent from *O. montheleni*), somewhat lower than the adjacent anteroconid lobes. Upper molars shape is comparable with the description of *O. debrujini* from Maritsa 1 reported in Martín Suárez & Mein (1991) for the specimens originally described as *Castillomys debrujini* by Şen et al. (1989), yet the presence of tma in m1 and a non-compatible size would prevent an attribution to this species and to the subgenus *Rhodomys* in general. The presence of tma in first lower molars, the sporadic presence of t12 and the moderate degree of stephanodonty allow a tentative attribution to *Hansdebruijnia* sp. For the moment, we refrain from assigning the Moncucco material to any known or new species.

A species of *Apodemus* is also present in the assemblage. It fits well in morphology with *A. etruscus*. t1 and t2 are connected and sometimes a t1 bis is present. t6 and t9 are connected and t12 is always present. The M1 is three-rooted. Size (L M1 1.75-2.19, avg. 1.95) perfectly fits in the range of the type population of *A. etruscus* (L M1 1.82-2.06, avg. 1.95; Engesser 1989). We tentatively attribute this material to *Apodemus* cf. *A. etruscus*, a MN 13-14 species.

A fourth species of murid is present, of large size and with brachyodont molars. Some characters of upper molars (M1 with t6-t9 connected, t4-t8 connected by a low crest and t7 present in 50% of the specimens; M1-2 with well developed t9, t12 present and reduced) may suggest a similarity with the genus *Huerzelerimys*. However, given the scantiness of the recovered material, for the present study, we prefer to classify this material as aff. *Huerzelerimys* sp.

Three species of Gliridae have been found in Moncucco. Two of them are Glirinae. The first one is *Glis minor*. This species is known from some uncertain remains from the early Turolian of Austria (Kohfidisch: Bachmayer & Wilson 1983, 1985), the Turolian of Germany (Dorn-Dürkheim; Tobien 1980) and the late Turolian of Greece (Maramena; Daxner-Höck 1995). One tooth found in Lissieu (Late Turolian of France) was described as *Glis* sp. but, according to the authors, it could belong to *Glis minor* (Hugueney & Mein 1965). The first reliable record of the species is in MN14 of Poland (Kowalski 1963). The species persists in central-eastern Europe until MN16 (Daoud 1993 and references therein). *Glis minor* is also reported at Les Valerots (Early Pleistocene; Erbajeva et al. 2001). In Italy *Glis minor* is known from the latest Villanyian of Rivoli Veronese and the early Biharian of Steggio (Kotsakis 2003 and references therein).

The second Glirinae has been determined as *Muscardinus* cf. *M. vireti*. This species is present since early Turolian to the beginning of late Turolian and is thought to be replaced, at least in Spain, in the final part of the Turolian by *M. meridionalis* (García-Alix et al. 2008). In Italy the genus was reported from Baccinello V3 (*M.* aff. *M. vireti*, early Messinian of Tuscany: Engesser 1983), Brisighella and Ciabòt Cagna (*Muscardinus* sp., post-evaporitic Messinian of Emilia-Romagna and Piedmont: Kotsakis 2003 and references therein).

The third species of Gliridae belongs to the Dryomyinae subfamily. It has been identified as *Eliomys* cf. *E. truci*, whose biochronological range starts from the Middle Miocene of Spain (Daams & Freudenthal 1988) until the Ruscinian (Daams 1999).

5. Taphonomical remarks

Taphonomical indications were obtained from molluscs and large mammal remains.

Freshwater and terrestrial molluscs are usually represented by small-sized specimens (average diameter <5 mm). The shells are perfectly preserved, without mineralogical alteration nor decalcification. Apex and protoconchs are always originally preserved. The fossils are empty in most whorls with traces of sediments limited to the last one. Large-sized specimens appear deformed due to compression (e.g.: the helicid *Eobania* sp., occasionally present in levels 3-5: Fig. 4.7). Thus, freshwater and terrestrial molluscs can be classified as resedimented fossils (sensu Fernández-López 1991) that underwent only one burying phase and are thus coeval with the encasing sediments. On the other hand, the shells of brackish-water molluscs appear robust, but are always decalcified and incomplete, univalve and showing abrasions due to rolling. Their preservation state indicates they are taphonomically reworked fossils (re-elaborated sensu Fernández-López 1991) from "Lago-Mare" facies levels. Thus, we are clearly dealing with different mollusc taphorecords within Moncucco fossil assemblages: one taphorecord includes the resedimented fossils, whereas the second taphorecord refers to the reworked fossils that experimented at least a double fossil diagenesis process. Nevertheless the age difference of these taphorecords is supposed to be minimal as the "Lago-Mare" sediments (level 1 of the sampled section) just underlie the fossil-bearing levels.

The large mammal bones are usually well preserved, orange-brown to dark brown. Weathering is not present on bone surface: only one specimen shows longitudinal cracking related to stage 1 described by Behrensmeyer (1978) that implies a very short exposure (a few days) on the soil surface after the death of the animal and before the burial. Bones are not much abraded and do not show indications of long distance transport. Small-sized bones usually are complete, whereas large-sized bones samples in level 4 are fractured. In level 4, medium to large-sized bones are broken with irregular, perpendicular fractures, consequent to breakage of fresh bone, sometimes linked with deformation probably due to post-depositional tectonic episodes (bent cervid mandible in Fig. 5.3). Root etching marks are frequent on bones: the etched grooves are dendritic to sinuous, lighter than the unetched surface. The presence of root etchings is interpreted as the results of roots or fungi in direct contact with the bone surface after burial (Behrensmeyer 1978; Lyman 1994). Roots may also cause splitting and fragmentation of bones (e.g. the bovid metatarsus in Fig. 5.8). The large mammal remains here examined can be classified as resedimented fossil (Fernández-López 1991).

6. Discussion

6.1. Depositional environments

On sedimentological and palaeontological basis (respectively texture and lithology and ostracod and mollusc content), it has been possible to reconstruct the sedimentary facies of most layers of the Moncucco section.

Layer 1 accumulated in shallow, brackish waters ("Lago-Mare" facies) as testified by the ostracod *Amnicythere propinqua*.

The absence of any internal texture (e.g. imbrication of pebbles) in layers 2 and 3 could reflect deposition from debris-flows in submerged environment. On the other hand, in the layers 4 to 6, the frequent lamination within the sandy clays and the coalescence of the conglomeratic lenses indicate repeated river overflowing with laminar currents and feeble erosional actions respectively, affecting the older deposits (cf. reworking of brackish molluscs) and the calcareous palaeosoils as well. In particular, layer 6 seems to be correlatable with a phase of no water influx, possibly due to the shifting of river direction, reduction of sedimentation rate and development of an incipient calcareous palaeosoil.

Layer 7 was deposited in a freshwater environment, with neighbouring woody areas subject to frequent and heavy rainfalls, as indicated by the presence of molluscs taxa that tolerate ipohaline waters, as Physidae, Sphaeriidae, and terrestrial forms as Aciculidae, Pyramidulidae, Clausiliidae, Limacidae, among others.

6.2. Biochronological considerations

According both to stratigraphic evidences and to ostracod and brackish-water mollusc taxa, the Moncucco fossil assemblages can be referred to the post-evaporitic Messinian. Thus, we consider that Moncucco Torinese may be one of the very rare Late Miocene Italian mainland continental faunas.

Small mammal assemblage gives additional support to this age inference. Indeed, the presence of *Centralomys* cf. *C. benericettii, Apodemus* cf. *A. etruscus* and *Prolagus sorbinii* suggest the fauna can be referred to MN13 (late Messinian).

6.3. Palaeobiogeographical considerations

Identified ostracods show a Paratethyan affinity. As for molluscs, the fossil assemblage of brackish-water taxa is of Paratethyan affinity too; it is similar to that of several other NW and central Italy Messinian localities bearing a "Lago-Mare" fauna: Narzole, Benevagienna, Castelletto d'Orba, Gavazzana, Rio Mazzapiedi (Sacco 1887), Corneliano d'Alba (Cavallo & Repetto 1988), Benevagienna (Sturani 1976) in Piedmont; Brisighella in Emilia-Romagna (Esu & Taviani 1989); Pietralacroce in the Marche Region (Esu & Girotti 2008); Bacino di Valdelsa in Tuscany (Abbazzi et al. 2008). The terrestrial taxa point to a European origin.

Small mammals indicate that Moncucco was a cross-road for immigration into the Italian peninsula. Actually there are taxa of eastern European origin as *Prolagus sorbinii* (Angelone 2007) and *Hansdebruijnia* sp. (these new finds would extend the range of this genus to the west) and of taxa widespread in western Europe as *Huerzelerimys* (whose easternmost occurrences are recorded in Italy: Mein et al. 1993), together with species known only from the Italian peninsula as *Centralomys* cf. *C. benericettii*.

7. Conclusions

The Moncucco Torinese section (Piedmont, NW Italy) consists in terms of the post-evaporitic, uppermost Messinian "facies a *Congeria*". The Moncucco site bears one of the rare post-evaporitic Messinian fossil assemblages of Italy. Both stratigraphical and palaeontological evidences (ostracods, brackish-water molluscs and small mammals) concur to give this age estimation. Marked age differences along the section can be excluded, in spite of the presence of a mixing of in-situ fossils (coeval with the encasing sediments) and taphonomically reworked specimens. This assumption is supported by the following evidences: the source of the brackish water molluscs directly underlies the continental layers, the boundary in between corresponds to a simple erosional surface, and the in-situ fossils are taxonomically homogeneous in all the analyzed layers.

Palaeobiogeographical data obtained from the diverse small mammals enhance the importance of NW Italy as a pathway for immigration into the Italian peninsula during the latest Messinian.

It will be worth to implement the present results by the study of the abundant samples recently collected. Additional information from large and small mammals is fundamental for comparison with the data obtained from coeval localities of NW Italy, Italian peninsula and the northern peri-Mediterranean area. Especially for small mammals, further studies may clarify some systematic attributions and contribute to revise the temporal and/or geographical distribution of some taxa.

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