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FOSSO DELLA FITTAIA: THE OLDEST TUSCO-SARDINIAN LATE MIOCENE ENDEMIC VERTEBRATE ASSEMBLAGES (BACCINELLO-CINIGIANO BASIN, TUSCANY, ITALY)

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Abstract. The Late Miocene continental successions of the Baccinello-Cinigiano basin (Grosseto), one of the longest and most continuous vertebrate-bearing continental successions in the Neogene Italian record, yielded at least four superimposed vertebrate assemblages bracketed in the time span 8.3 - 6.4 Ma. The Baccinello-Cinigiano basin is famous for recording endemic vertebrate assemblages that include the youngest European Miocene hominoid, *Oreopithecus bambolii*.

The late Miocene endemic vertebrate fauna known as the Baccinello V0 assemblage is the oldest vertebrate fauna within the Baccinello-Cinigiano basin succession, being correlated to the European mammal Neogene unit MN11. Recent field surveys along the Trasubbie river allowed studying in detail the basal Baccinello-Cinigiano sedimentary succession, and sampling fossiliferous level bearing microvertebrates along the small creek Fosso della Fittaia. The sample "Fosso della Fittaia 2013" yielded about 170 fossil remains improving our documentation of the oldest vertebrate assemblages from the Baccinello-Cinigiano basin. As far as rodents are concerned, in addition to the already recognized murid *Huerzelerimys* and glirid *Anthracoglis*, a few dental remains are assigned to a new genus and species of giant dormouse. It is further worth noting the occurrence in the sample of shrew remains (the first described from the Baccinello-Cinigiano basin) identified as cf. *Lartetium*. The latter attests the presence of a crocidosoricine in the Fosso della Fittaia 2013 assemblage, postdating the youngest known occurrences of the subfamily by at least 1 my. The vertebrate assemblage is completed by a diverse herpetofauna and the first fish remains reported from the basin.

INTRODUCTION

The late Miocene continental successions of the Baccinello-Cinigiano basin (hereafter BCB) are located in the Grosseto district in southern Tuscany (Italy) and record at least four superimposed vertebrate bearing horizons bracketed within the time span ranging from 8.3 to 6.4 Ma (Benvenuti et al. 2001; Rook et al. 2011; Rook 2015). The BCB is one of the longest and most continuous vertebrate bearing continental successions in the Italian Neogene record, and it is famous for recording the youngest European Miocene hominoid, *Oreopithecus bambolii* (Hürzeler 1951, 1958; Harrison & Rook 1997; Moyá Solá & Köhler 1997; Casanovas Vilar et al. 2011a). This record is part of endemic and taxonomically poor vertebrate assemblages, termed *Oreopithecus* Zone Faunas (OZF in Bernor et al. 2001), which include rodents, bovids, suids and no carnivores other than crocodiles (Delfino & Rook 2008), and otters (Rook et al. 1999). The low taxonomic diversity, high degree of endemism, absence of terrestrial carnivores, the tendency of rodents to attain a larger size as compared to their mainland relatives and the presence of unique adaptations in many taxa (including *Oreopithecus*) point to an insular character of the OZF that was already recognized by Hürzeler & Engesser (1976). This is further supported by palaeogeographic data, which indicate that during most of the Miocene Italy was an archipelago isolated from the European mainland and divided into distinct bioprovinces that correspond to different sets of islands (Rook et al. 2006).

The occurrence of different vertebrate faunal

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assemblages at Baccinello is known since the 1950's (De Terra 1956), thanks to the early research led by J. Hürzeler from the Basel Naturhistorisches Museum (Gillet et al. 1965; Lorenz 1968; Rook 2012) who recovered abundant faunal remains from different stratigraphic levels (Hürzeler & Engesser 1976). This allowed dividing the BCB record into four successive biochronological units termed V0 to V3 (Lorenz 1968; Engesser 1989; Rook et al. 1996). The mammal fauna of the V1 and V2 assemblages is completely endemic, while that of the V0 and V3 is not, allowing a correlation to the European Neogene Mammal units (MN; for updated reviews see Mein 1999; Agustí et al. 2001; Hilgen et al. 2012).

The late Miocene "Baccinello V0", the oldest vertebrate fauna within the BCB succession, is correlated to MN11, which would imply a maximum age of 8.9 Ma (ages according to Hilgen et al. 2012). The Baccinello V0 assemblage, which includes mostly small mammals, was recovered in 1985 by researchers of the Basel Naturhistorisches Museum from grey marls situated about 7 m below the lignite correlated with the lignite of Baccinello V1 along the Fosso della Fittaia creek. Part of this material was described by Engesser (1989), who reported about the murid remains. According to the latter author the V0 fauna includes Rodentia (*Huerzelerimys vireti* and *Anthracoglis marinoi*), Ochotonidae (*Paludotona* cf. *etruria*), Soricidae indet., and Artiodactyla (*Tyrrhenotragus* sp.; Bovidae indet.). The occurrence of Chiroptera indet. was not listed in Engesser (1989), but has been reported in faunal lists in later general publications based on information derived from NMHB collections (Kotsakis et al. 1997; Rook et al. 1996, 1999). The presence of the non-endemic murid *Huerzelerimys vireti* allows for the correlation of the V0 fauna to the MN11 (Engesser 1989).

In summer 2013, as part of the first author (OC) thesis for the 3-years Degree in Natural Sciences, field surveys along the Trasubbie river were performed with the aim of increasing our knowledge of the geology of the BCB and the vertebrate fossil record of the late Miocene of southern Tuscany. The good outcrop conditions allowed us to study in detail the sedimentary succession cropping out along the small creek Fosso della Fittaia, to identify fossiliferous levels, and to proceed with sediment sampling for screen-washing. This resulted in the recovery of about 170 microvertebrate fossils from a new fossiliferous level along the Fosso della Fittaia creek (site acronym: FdF2013). Herein we describe these new vertebrate remains and discuss on their biochronological implications.

MATERIALS AND METHODS

In order to recover microvertebrates we followed the classical approach described by MacKenna (1962). The total of 100 kg of sediment sampled was completely dried. Afterwards, it was immersed in water which produced its disaggregation. The sediment was then screen-washed using professional wet sieves (Controls Srl) with mesh sizes of 10, 2.5, 0.7 and 0.5 mm respectively. Screen-washing removed all the mud and left a residue that has been inspected under a stereomicroscope in order to recover and isolate the small mammal remains and other vertebrate fossils.

The measurements of the soricid dental elements and their description follow the methodology and the nomenclature specified in Reumer (1984). The classification of rodents used in this work follows Wilson and Reeder (2005), while the terminology and measurement method follow Daams (1981) and García-Paredes et al. (2009) for the Gliridae, and Van de Weerd (1976) for the Muridae. Estimated measurements (due to minor damage) are given within parentheses. Measurements were taken using a Nikon Measuroscope 10 optic caliper. The drawings of the specimens were performed using a Leica light camera mounted on a Leica MZ6 stereomicroscope. Plots (Fig. 7) have been created using Past (version 3.04), a free software for scientific data analysis developed by Øyvind Hammer (University of Oslo) and available for download at http://folk.uio.no/ohammer/past/. All the material studied in the systematic part of this work is housed within the collections of the Museo di Storia Naturale dell'Università di Firenze (Sezione Geologia e Paleontologia).

Abbreviations. Institutions: IGF, Museo di Storia Naturale, Sezione Geologia e Paleontologia, Università di Firenze; NHMB, Naturhistorisches Museum Basel. Measurements: H, height; L, length; LT, length of the talon; W, width; TRW, trigonid width, TAW, talonid width.

GEOLOGICAL SETTING

The BCB is located east of the Mid Tuscany Metamorphic Ridge, a structural high that during the late Tortonian-Messinian separated western continental-marine from eastern fully continental basins. The basin shoulders are made of late Oligocene turbidite sandstones (Tuscan Units) on the west and of late Cretaceous chaotic claystone with limestone blocks (Ligurid Units) on the southern and eastern margins.

The BCB is filled by a fluvio-lacustrine, dominantly clastic succession exposed for about 250 m, which has been subdivided into two unconformity-bounded stratigraphic units (synthems, CB1 and CB2; Benvenuti et al. 2001, 2015; Rook et al. 2011; Marroni et al. 2015).

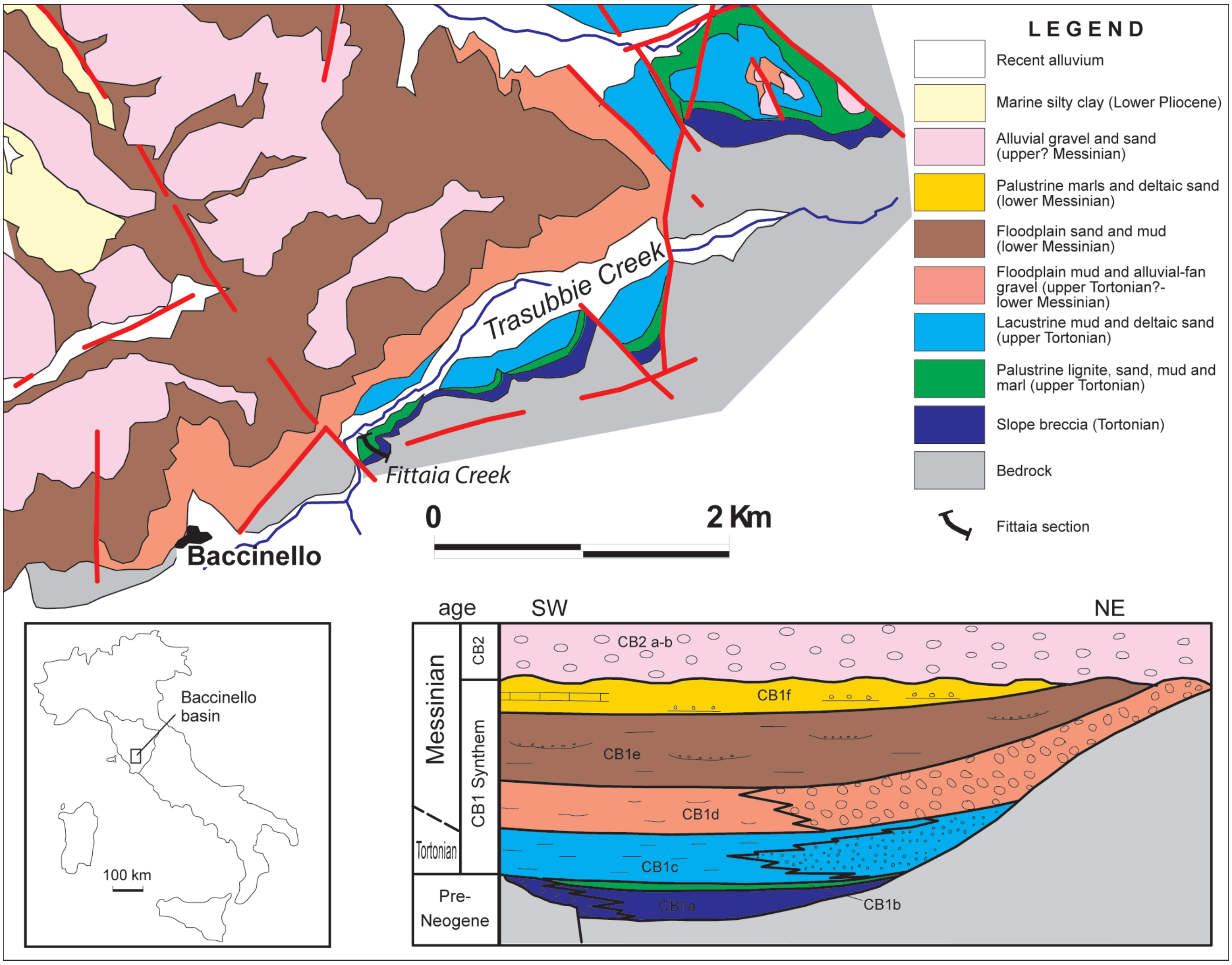

Fig. 1 - Location map with a simplified geologic map of the southern portion of the Baccinello-Cinigiano Basin (BCB) and a stratigraphic scheme of the BCB succession (modified from Rook et al. 2011).

Synthem CB1 (upper Tortonian-lower Messinian) includes six units, which document an articulated depositional evolution. The lowermost unit CB1a records the development of limited colluvial fans (Fig. 1; Benvenuti et al. 2001, 2015) at the base of the southern basin shoulder later evolved into poorly drained alluvial plains, whose deposits bear the vertebrate-bearing level described in this paper (see details below). The overlying unit CB1b attests to the successive development of a shallow lake characterized by organic and carbonate deposition (Fig. 1; Benvenuti et al. 2001; Marroni et al. 2015), where endemic V1-mammal remains accumulated (Lorenz 1968; Rook et al. 2011). Unit CB1c points to the full establishment of a shallow terrigenous lake characterized by delta progradation from ESE (Benvenuti et al. 2001). Along the eastern margin of the basin, the transition between units CB1c and CB1b is marked by an angular unconformity, hinting to a local deformation pulse due to syn-depositional uplift of the basin shoulders in a compressional regime (Bonini et al. 2014).

The following unit CB1d, documents alluvial fans prograding from the eastern basin margin into a muddy alluvial plain which replaced the former shallow lake. This endorheic alluvial setting was populated by the V2 mammal fauna (Benvenuti et al. 2001; Rook et al. 2011). Unit CB1e records persisting alluvial deposition in a plain crossed by an axial river that entered the basin from the north testifying to drainage opening compared with the previous closed alluvial plain. CB1e bears the V3 fauna, which can be correlated to the MN13 unit (7.4/6.8-5.3 Ma; after Hilgen et al. 2012) and indicates a full biogeographic connection of the basin with mainland Europe (Benvenuti et al. 2001; Rook

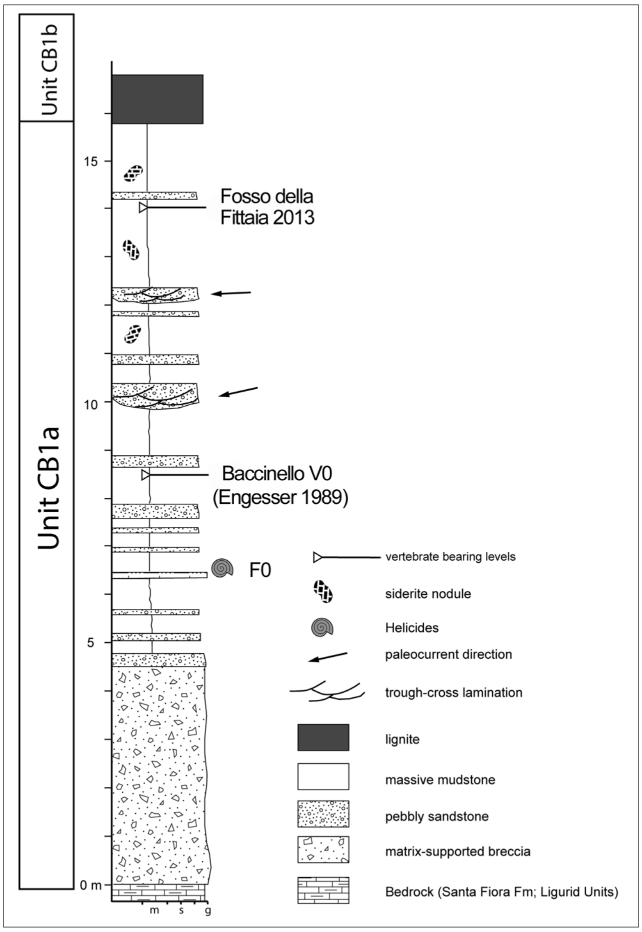

Fig. 2 - Fosso della Fittaia stratigraphic log with position of the horizon rich in land snails Helicidae indet. ("F0"), and the vertebrates bearing levels "Fosso della Fittaia 2013" (present study) and Baccinello V0. The position of the latter is indicated at seven meters below the lignite seam, according to the original description by Engesser (1989: 233).

et al. 2011). Finally, unit CB1f testifies to renewed fluvio-lacustrine conditions characterized by deltaic sand supply from the north, spreading to the south in a shallow carbonate lake (Benvenuti et al. 2001).

Resting on the previous deposits through a high-relief erosional unconformity, synthem CB2 (upper Messinian-lower Zanclean), documents a drastic environmental change related to the deep incision of the basin fill by a fluvial valley adjacent to the western BCB margin and directed to the south. Units CB2a and CB2b, consisting of fluvial conglomerates, sandstones and mudstones, record two major stages of valley filling (Benvenuti et al. 2015). During the early Pliocene (Bossio et al. 1991), the residual valley funnelled a marine transgression from south to north, which is evidenced by marine mudstones unconformably resting over the CB2 deposits.

BIOCHRONOLOGY/MAGNETOSTRATIGRAPHY

The BCB succession has long been lacking a reliable chronological calibration, although synthem CB1 includes four successive local biochronologic units spanning from the very base (Baccinello V0) to the top (Baccinello V3). Both faunal assemblages V1 and V2 (the best known since the early investigation in the basin) exhibit such a high degree of endemism that do not allow for biostratigraphic correlations with other European sites (Engesser 1989; Rook et al. 1999). The occurrence of the non-endemic murid *Huerzelerimys vireti* in the Fosso della Fittaia fauna (the so called "Baccinello V0 assemblage"), where it is associated with already endemic taxa such as *Anthracoglis marinoi*, allowed for a reliable correlation of this fauna to the MN11 unit of the Neogene European biochronologic scale. On the other hand, the youngest faunal assemblage (Baccinello V3) is comparable with European localities correlated to MN13 (Bernor et al. 2011; Engesser 1989; Rook et al. 1996).

The discovery of volcanics interbedded within unit CB1c (first reported by Lorenz 1968) provided a first and yet the only spike for a radiometric age constraint of the BCB vertebrate-bearing sediments. ^{40}Ar/^{39}Ar dating of biotite crystals, placed between units V1 and V2 yielded an age of 7.55±0.03 Ma (Rook et al. 2000).

A magnetostratigraphic sampling of the BCB succession recently provided further data for a robust stratigraphic correlation. The local magnetostratigraphic succession could be correlated to the Geomagnetic Polarity Time Scale allowing to constrain the age of the endemic faunas between 8.3 and 6.7 Ma (Benvenuti et al. 2015; Rook et al. 2011). The oldest vertebrate bearing sediments in BCB, crop out along Fosso della Fittaia section, where the Baccinello V0 assemblage is stratigraphically situated about 7 m below the massive lignite correlated with Baccinello V1. This section shows a reversed polarity and is correlated to the upper part of chron C4r (C4r.1r), which would imply an age between 8.3 and 8.1 Ma (Rook et al. 2011). Even though this is the preferred correlation, an alternative correlation to the lower part of chron C4r (C4r.2r) is also possible, and this would yield a somewhat older age for the Baccinello V0 fauna, closer to 8.7 Ma (Rook et al. 2011).

THE FOSSO DELLA FITTAIA SECTION

In the summer of 2013 a natural exposure of the lowermost portion of synthem CB1, known as the Fosso della Fittaia section (Figs 1, 2), was discovered, which had been made well accessible due to catastrophic erosion caused by large floods during the preceding autumn. Unit CB1a was exposed also in portions previously covered by vegetation and talus scree allowing a more complete observation and sampling of these deposits. We were able to describe a section log of about 16 meters measured from the stratigraphic contact with the Ligurid bedrock basement of the basin, to the contact with unit CB1b (Fig. 2).

Less than five meters of matrix-supported calcareous breccias rest directly onto the Ligurid Units. Clasts are polymodal with blocks up to 30 cm in diameter. These deposits are ascribed to debris flows sourced from the Ligurid bedrock prone to develop sediment gravity flows along the southern slopes of the basin and accumulated into small colluvial fans at the footslopes. The overlying deposits up to about ten meters from the base of the series, consist of greyish massive mudstones with intervening beds of massive or graded pebbly sandstone of centimetric to decimetric order. A peculiar horizon is represented by mottled marly mudstone bearing shells of land snails (Helicidae indet.; D. Esu, pers. comm. 2015), a terrestrial mollusc fauna not recognized before (Gillet et al. 1965; Lorenz 1968). On the whole this portion is ascribed to a floodplain dominated by mud settling in poorly oxygenated conditions and occasionally affected by overbank deposition of coarser sediment eventually spreading from nearby channels. The land snail-bearing horizon - that we name here “F0”, according to the basin scheme proposed by Gillet et al. (1965) and Lorenz (1968) - is referred to a paleosol attesting to relative quiescence of deposition. A test sampling for microvertebrate search was performed but, once screen-washed, proved sterile.

The upper portion of the series consists of mudstones similar to the previous ones, except for the occurrence of isolated siderite concretions. Lenticular beds of pebbly sandstone of decimetric thickness are interbedded within the mudstones, showing crude trough-cross lamination that indicates a paleocurrent directed to WSW. This part of the unit supports the interpretation of the sedimentary environment as an alluvial setting possibly undergoing rise in the watertable. Mudstones will correspond to a poorly-oxygenated floodplain though siderite nodules, which are more common in the uppermost portion of the section (Fig. 2), suggesting the occurrence of temporary shallow water bodies. Siderite may form in river bogs and marshes (Pye 1981; Postma 1977) and is reported to occur at the alluvial-palustrine facies transition (Cabrera et al. 1995). Pebbly sandstones would correspond to the infill of shallow and narrow channels by downcurrent migration of small sinuous-crested dunes. Unexpectedly, the channel evidence hints to limited streamflow along the southern margin running westward in the early development of the BCB. The occurrence of fragmentary bones in the highest portion of this part of the succession (about 2 m below the lignite; Fig. 2) marks the interval sampled for screen washing (FdF2013). The log is topped by a lignite seam recording the organic-rich lacustrine environment of unit CB1b.

Matson et al. (2012), analysing the $\delta^{13}C$ and $\delta^{18}O$ stable isotope record from organic matter in BCB palaeosols, have provided data on the Fosso della Fittaia section here studied. Matson et al. (2012) analysis on the $\delta^{13}C$ stable isotope record from organic matter in palaeosols throughout the BCB succession shows very low variability relative to the range for modern plants, implying plant ecosystem stability through time.

THE NEW FOSSIL REMAINS FROM FOSSO DELLA FITTAIA

The 2013 sampling of a vertebrate-bearing layer along the Fosso della Fittaia section (FdF2013), resulted in the recovery of almost 170 fossil remains that have improved our knowledge of the BCB oldest faunal assemblages. In addition to *Huerzelerimys oreopitheci* and *Anthracoglis marinoi*, the FdF2013 assemblage includes a few isolated teeth that permit identifying the occurrence of a giant dormouse (fully comparable with “Gliridae nov. gen. et nov. sp.” from Baccinello V1; Engesser 1983). Moreover, our sample also yielded a few specimens of a shrew attributable to the subfamily Crocidosoricinae, as well as several elements of the herpetofauna and the first fish remains reported from the basin.

TELEOSTEI
Order **Gobiiformes** Günther, 1880
Family Gobiidae Cuvier, 1816
?Gobiidae indet.

Fig. 3

Material: IGF102232, a single fragmentary left premaxilla.

Description. The available material consists of a single fragmented bone representing an incomplete left premaxilla lacking both the proximal and distal ends (Fig. 3). The specimen represents a portion of a robust alveolar process bearing a well-developed postmaxillary process along its smooth dorsal surface. A relatively broad alveolar shelf is present on the ventral side of premaxilla, characterized by numerous rounded sockets of teeth. These are irregularly arranged into three rows. Those of the outer row are notably enlarged and irregularly spaced. The innermost series is only present in the anterior half of the preserved portion of the premaxilla. The postmaxillary process is crest-like with a regularly convex dorsal profile.

Remarks. Due to its fragmentary nature, the taxonomic placement of this specimen is rather problematic. However, the presence of the postmaxillary process suggests that the premaxilla can be referred to a percomorph fish (e.g., Keivany 2014). Within this highly diverse and heterogeneous clade of teleost fishes, the overall morphology of the (preserved part of the) premaxilla and, particularly, the arrangement and configuration of the sockets of teeth are consistent with those of a number of species of the family Gobiidae (see, e.g., Birdsong 1975; Miller 1977; McKay & Miller 1997; Herler et al. 2006), to which the specimen is tentatively referred.

Fig. 3 - Gobiidae indet. from FdF2013, IGF102232, alveolar process of left premaxilla in dorsal A) and ventral B) views. Scale bars 1 mm.

AMPHIBIA
Order **Anura** Fischer, 1813
Family Alytidae Fitzinger, 1843
Subfamily Discoglossinae Günther, 1859
Discoglossinae indet.

Fig. 4A, B

Material: IGF102233: one fragmentary right ilium; IGF102234: one fragmentary right ilium; IGF102235: three fragmentary right ilia.

Description. The only ilium that preserves a significant part of the posterior region (IGF102234; Fig. 4A, B) shows a clear groove on the posteromedial surface, which gives origin to a medial notch on the contact surface with the ischium. All the other ilia share with IGF102233 a small size as well as the presence of crista dorsalis and a modest, low but long tuber superior. Where the two latter structures are well preserved, the tuber gradually merges with an evident but proportionally low crista dorsalis. The ilia preserving the anteroventral edge of the acetabulum and at least part of the pars descendens, show that the latter was quite reduced anteroventral to the acetabulum. None of the ilia has an evident supracetabular fossa.

Remarks. The presence of a groove on the posteromedial surface, and therefore the presence of a notch on the contact surface of the ilium with the ischium, is a typical character of *Discoglossus* and *Latonia*, the two representatives of the Discoglossinae. All the other characters are compatible with such an identification. On the basis of the available morphological traits it is not possible to discriminate between the two above mentioned genera, but the small size could suggest the exclusion of *Latonia*, whose extinct representatives had a large, or even very large, size (Roček 1994). Both *Discoglossus* and *Latonia* were already present in the Miocene of Europe as recently summarised by Biton et al. (2013). The Italian fossil record of the Discoglossinae comprehends both genera and hosts the geologically youngest fossil representa-

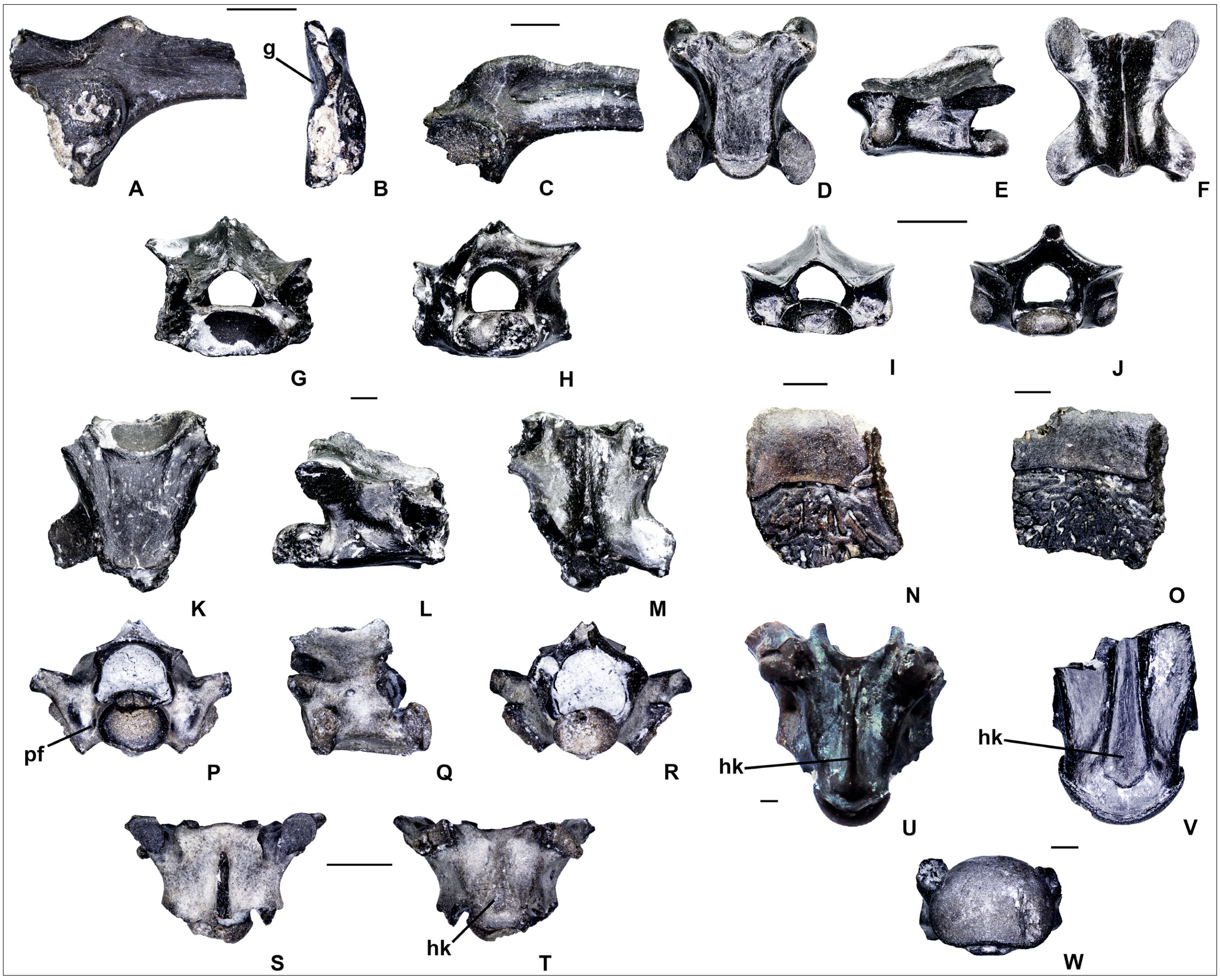

Fig. 4 - Amphibians and squamates from FdF2013. A-C - Right ilia of Discoglossinae indet.: IGF102233 in lateral A) and posterior B) views and IGF102234 in lateral C) view. D-F, I, J - Trunk vertebra (IGF102243) of *Anguis* sp. in ventral D), left lateral E), dorsal F), anterior I) and posterior J) views. G, H, K-M - Trunk vertebra (IGF102244) of Anguinae gen. et sp. indet. in anterior G), posterior H), ventral K), right lateral L) and dorsal M) views. N, O - Osteoderms (IGF102247, N, and IGF102248, O) of Anguinae gen. et sp. indet. in external view. P-T - Trunk vertebra (IGF102251) of cf. Erycinae indet. in anterior P), left lateral Q), posterior R), dorsal S) and ventral T) views. U-W - Trunk vertebrae of "colubrines" gen. et sp. indet.: IGF102252 in ventral U) view and IGF102253 in ventral V) and posterior W) views. Abbreviations: g, groove; hk, hemal keel; pf, paracotylar foramen. Scale bars = 1 mm.

tive of *Latonia* (Delfino 2002), a genus considered extinct since its description, but unexpectedly found alive in Israel a few years ago (Biton et al. 2013).

Anura indet.

Material: IGF102236: one squamosal, one mandible, one humerus, two femura, ten tibiofibulae, one vertebra, one urostyle, and three indeterminate fragments.

Remarks. Most of the fragmentary anuran remains have a size congruent with that of the discoglossine ilia, but, being too fragmentary and devoid of diagnostic features they are referred at Order level.

REPTILIA

Order **Testudines** Linnaeus, 1758
Family Testudinae Batsch, 1788
Genus *Testudo* Linnaeus, 1758

Testudo sp.

Fig. 5

Material: IGF102237: isolated right ilium; IGF102238: fragmentary cervical vertebra; IGF102239: 24 fragmentary girdle, appendicular or vertebral fragments; IGF102240: six costal fragments, one partial peripheral and 27 shell fragments; IGF102241: one block of sediment hosting several shell and few girdle and appendicular elements; IGF102242: one isolated partial left xiphiplastron.

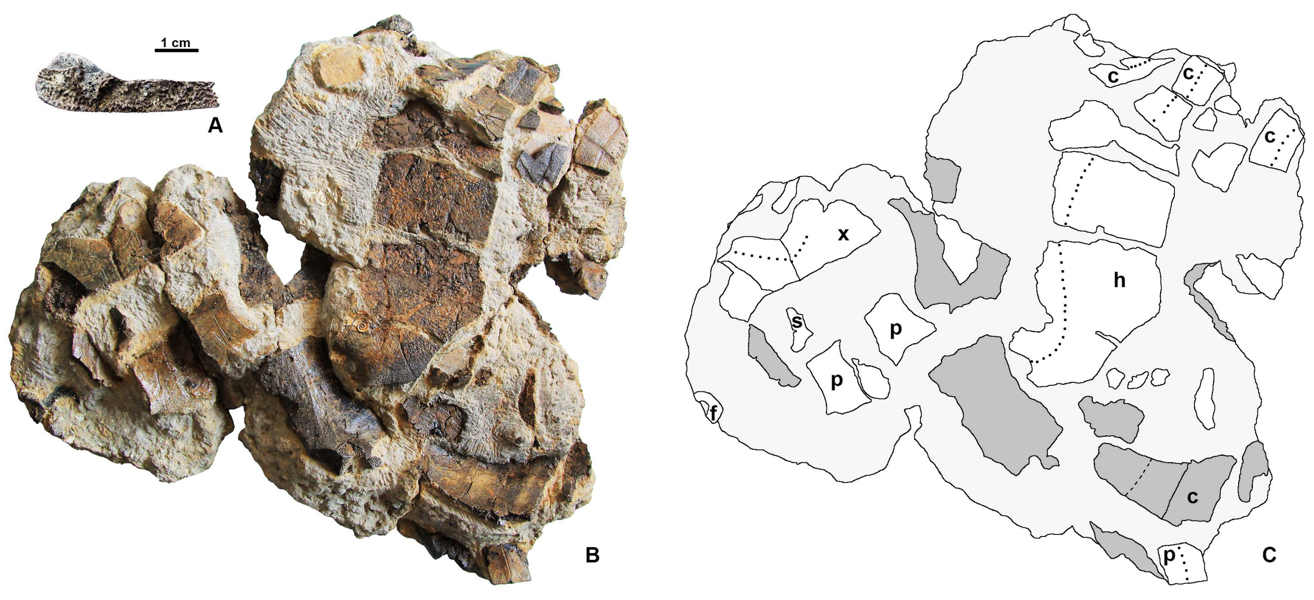

Fig. 5 - *Testudo* sp. from FdF2013. A) isolated partial right xiphiplastron (IGF102242) showing the vertical suture with the corresponding hypoplastron. B, C) block of sediment hosting several shell and few girdle and appendicular elements (IGF102241) and its interpretative drawing. Dark gray indicates the shell elements exposing the visceral surface devoid of scute sulci. Abbrevations: c, costal; f, possible femur fragment; h, hypoplastron; p, peripheral; s, scapula; x, xiphiplastron.

Description. The shell elements of the slab IGF102241 and the isolated partial left xiphiplastron IGF102242 are the most informative remains (Fig. 5A). In particular, among the shell elements exposing the external surface, the block hosts a pair of hypoplastra and a pair of xiphiplastra preserving the scute sulci. The abdomino-femoral sulci on the hypoplastra are very much arched laterally and do not reach the hypo-xiphiplastra suture medially. The femoro-anal sulci reach medially about the mid of the inter-xiphiplastral suture; they are straight and somehow parallel to the rim of anal notch. The latter is rather open (more than 90°). None of the peripheral elements shows the external surface and therefore the position of the pleuro-marginal sulcus cannot be ascertained. The costal elements are too fragmentary to appreciate their shape. IGF102242 is an isolated partial left xiphiplastron that preserves the anterior portion. It is morphologically congruent with the ones on the block, has a mediolateral breadth (from the inter-xiphiplastral suture to the lateral edge) of 56 mm and a thickness varying from 8.2, along the inter-xiphiplastral suture, to 16.3 mm, along the medial edge of the dorsal fold of the femoral shield. The latter fold becomes distinctly broader in posterior direction. The anterior edge of the xiphiplastron hosts a regular, vertical sutural surface that indicates the absence of a hypo-xiphiplastral hinge. The isolated right ilium IGF102237 is complete and 55.0 mm tall. It is slightly bent in medial direction so that the apex points posteromedially. The dorsal tip has a triangular shape, showing a nearly flat surface facing anteriorly (there is only a very modest vertical ridge) and a distinctly convex surface facing posteriorly characterized by a marked crest with a sharp edge.

Remarks. All the chelonian remains here reported are referable to different specimens of a tortoise of the genus *Testudo* characterized by the absence of the hypo-xiphiplastral hinge; arched abdomino-femoral sulci that do not reach the hypo-xiphiplastral suture medially; femoro-anal sulci nearly parallel to the broad anal notch, anteriorly reaching about the mid of the inter-xiphiplastral suture. This morphology is basically congruent with the one of *Testudo antiqua* Bronn, 1831 from the middle Miocene of Germany (see the recent revision by Corsini et al. 2014), but also to the late Miocene *Testudo amiatae* Pantanelli, 1892 from Fosso Merlaccione at Cinigiano, a V3 locality in the northern sector of the Baccinello-Cinigiano basin (Pantanelli 1892a, b; Chesi 2008; Vlachos et al. 2015). The validity of the latter species is still to be ascertained and therefore, even if it is likely that the material from Baccinello is conspecific to the one from Cinigiano, it is here referred only at genus level as most of the *Testudo* remains coming from the late Miocene of Tuscany (Vlachos et al. 2015). Several shell, appendicular and girdle fragments are tentatively referred to the same taxon.

Order **Squamata** Oppel, 1811
Suborder **Lacertilia** Günther, 1867
Family Anguidae Gray, 1825
Subfamily Anguinae Gray, 1825
Genus *Anguis* Linnaeus, 1758

Anguis sp.

Figs 4D-F, I-JX

Material: IGF102243: one trunk vertebra.

Description. IGF102243 is a well-preserved vertebra of small size (centrum length 2.1 mm; Figs 4D-F, I-JX). The neural arch is relatively depressed and characterized by a low neural crest that terminates in a spine that does not project beyond the posterior edge of the postzygapophyseal facets. The anterior edge of the neural arch is moderately convex in dorsal view, but markedly tectiform in anterior view. The neural canal is moderately broad. The pre- and postzygapophyses are tilted in dorsolateral direction; their facets are rather oval in shape. There is no hint of prezygapophyseal processes. Dia- and parapohyses are moderately developed and not distinctly separated from each other. The centrum, and therefore the cotyle and condyle, are markedly depressed dorsoventrally. The ventral surface of the centrum is flat, devoid of any trace of keel or hypapophysis, and laterally delimited by parallel edges that only anteriorly tend to modestly diverge. There is no hint of precondylar constriction.

Remarks. IGF102243 is a trunk vertebra clearly showing the adult morphology (among others, the neural canal is not as broad as in juvenile squamates) of a small-sized anguine lizard. The referral to anguine lizards, and to *Anguis* in particular, is based on the general morphology of the vertebra, and the flatness of the centrum that shows parallel edges in particular. The relative anteroposterior shortness of the centrum and the slightly diverging edges in the anterior region of the centrum could indicate that the vertebra comes from most anterior trunk sector. In absence of diagnostic osteological characters, the recent split of the extant species *Anguis fragilis* Linnaeus, 1758 into several different species (see a summary in Gvoždíka et al. 2013) hinders the specific identification of fossil material that, moreover, likely belongs to an extinct species that still has to be diagnosed.

Anguinae gen et sp. indet.

Figs 4G-H, K-M, N-O

Material: IGF102244: one trunk vertebra; IGF102245: highly fragmentary trunk vertebra; IGF102246: fragmentary tail vertebra; IGF102247: one osteoderm; IGF102248: one osteoderm; IGF102249: 38 osteoderms or osteoderm fragments.

Description. The incomplete trunk vertebra IGF102244 (Figs 4G-H, K-M) is relatively big in size (preserved centrum length of 5.4 mm). It shares several characters with the above described vertebra referred to *Anguis*, but differs in having strongly diverging lateral sides of the centrum. IGF102245 is the posterior region of the centrum of a large-sized trunk vertebra showing a flat ventral surface and the absence of precondylar constriction. The tail vertebra IGF102246 preserves only the portion posterior to the autotomic plane. The neural arch is devoid of a crest, but the neural spine is proportionally long and tall, and it is directed posterodorsally. The preserved portion of the centrum is 3.2 mm long and bears the traces of fused haemapophyses. All the available osteoderms (Fig. 4N-O) are characterized by being approximately rectangular or squared and relatively big in size (up to 4.4 x 4.3 mm). The external surface has an anterior, or anterior and lateral smooth surface. The rest of the surface is vermiculated by grooves/furrows and pustules/pits. Some of the osteoderms bear a longitudinal keel that divides the vermiculated surface.

Remarks. The morphology and size of the vertebrae and the osteoderms described above clearly differs from that of *Anguis* and is broadly congruent to that of non-*Anguis* anguine taxa. These are easily identifiable on the basis of tooth bearing elements (Klembara et al. 2014), but the identification of isolated vertebrae and osteoderms is still problematic because of the absence of comparative studies.

Lacertilia indet.

Material: IGF102250: one highly fragmentary tooth bearing bone, one frontal and five vertebral fragments.

Remarks. None of these highly fragmentary skeletal elements can be confidently identified because of preservational reasons.

Suborder **Serpentes** Linnaeus, 1758
Infraorder **Henophidia** Nopcsa, 1923
Family Boidae Gray, 1825
Subfamily Erycinae Bonaparte, 1831
cf. Erycinae indet.

Figs 4P-T

Material: IGF102251: incomplete trunk vertebra.

Description. IGF102251 (Figs 4P-T) is a very small vertebra whose original centrum length can be estimated to be approximately 1.8 mm, about the same as the width. The anterior edge of the neural arch is slightly convex medially, and markedly convex laterally. The neural crest and the posterior area of the neural arch is broken off, but it is clear that the crest barely reached the base of the zygosphene. The prezygapophyses are slightly tilted in laterodorsal direction. The prezygapophyseal processes are broken off at their base. The prezygapophyseal facets are oval-shaped. The neural canal (filled by the sediment that holds together some fragments of the vertebra) is moderately broad. The cotyle and the condyle are slightly wider than high. The paradiapophyses are eroded, but they were very well developed and separated from each other. Relatively large paracotylar and lateral foramina are present; the subcentral foramina are small. A thin and low haemal keel is clearly present.

Remarks. Most of the characters described above fit well with erycinae boid snakes (in particular, the small size and proportion of the centrum), but the presence of paracotylar foramina contrasts to the morphology of both *Eryx* and *Bransateryx* (Szyndlar & Schleich 1993, 1994), making the referral of the single, fragmentary vertebra IGF102251to Erycinae indet. very tentative. Further material could clarify this issue. Erycines are relatively rare in the Italian fossil record (see literature in Delfino 2002; Delfino et al. 2011) and represent the only fossil boid snakes so far described for Italy, as the type and only known specimen of *Python sardus* Portis, 1901 actually belongs to an undetermined acanthomorph fish (Delfino et al. 2014). Erycinae snakes were considered extinct in Italy, but, due to the absence of post-Pliocene fossils, the recent discovery of a viable population of *Eryx jaculus* in Sicily (Insacco et al. 2015) is probably related to a human introduction.

Infraorder **Caenophidia** Hoffstetter, 1939
Family Colubridae Oppel, 1811
"colubrines" sensu Szyndlar, 1991
"colubrines" gen. et sp. indet.

Figs 4V-W

Material: IGF102252: one fragmentary trunk vertebra; IGF102253: one vertebral fragment; IGF102254: one fragmentary trunk vertebra.

Description. Three fragmentary vertebral fragments are characterized by the presence of distinct haemal keel. The largest vertebra entirely preserving the centrum (IGF102252; Fig. 4U) has a centrum length of 8.6 mm, but the fragmentary centrum IGF102253 (Figs 4V-W) is slightly larger. The shape of the haemal keel varies from uniformly narrow and tall but posteriorly slightly spatulate (IGF102252 and IGF102254) to much broader and flat (IGF102253).

Remarks. Despite the fragmentary status of this material, the presence of haemal keel in vertebrae whose centrum is not wider than long allow identifying the informal taxon "colubrines" sensu Szyndlar (1991). The size of the remains and the variation in the shape of haemal keel suggests the presence of at least two different taxa. Delfino (2002) briefly described a fragmentary colubrine vertebra from Fosso della Fittaia, Baccinello V0 (NHMB collections), characterized by a similar size (centrum length: 8.9 mm; centrum width: 7.8 mm).

Serpentes indet.

Material: IGF102255: one fragmentary trunk vertebra, five fragments of a large vertebra, one fragmentary caudal vertebra.

Remarks. The fragmentary status of this material and the absence of diagnostic characters does not allow to identify it with precision. However, the largest remains could likely belong to the same colubrine taxa described above.

MAMMALIA
Order **Soricomorpha** Gregory, 1910
Family Soricidae Fischer, 1814
Subfamily Crocidosoricinae Reumer, 1987
Genus *Lartetium* Ziegler, 1989

cf. ***Lartetium*** sp.

Fig. 6, Tab. 1

Material: IGF102256: upper right incisor; IGF102257: isolated right m1; IGF102258: fragmentary right mandible with m1-m2; IGF102259: fragmentary right mandible with m2; IGF102260: fragmentary right mandible with m2-m3.

Description. *I1* (Fig. 6A): The root of the I1 is broken and the apex and talon of the upper incisor are worn, so only the intermediate part is preserved. The cervix is slightly concave, and there is a wide cingulum covering the base of the crown. The dorsal margin of this tooth is not complete, but the preserved part shows a regular curvature.

m1 (Figs 6B, C): The first lower molars have a trigonid narrower than the talonid. In occlusal view, this element acquires a rather triangular outline because the oblique cristid ends labially, so the reentrant valley is not much evident. The protolophid is perpendicular to the lingual margin.

m2 (Figs 6D, E): In the second lower molars, trigonid and talonid have a similar width. In this element, the reentrant valley is more developed than in the m1 and the protolophid is not completely perpendicular to the lingual margin, because the protoconid is more posteriorly placed than the metaconid. The angle between protolophid and paralophid in occlusal view is thus more acute than in the trigonid of m1.

m1-m2: The m1 and m2 share several characters such as the presence of a thin labial cingulid covering the base of m1 and m2 (which protrudes significantly under the paralophid in occlusal view), high entoconid cristids and the hypolophids bend posterolingually in the rear of their corresponding entoconids. Finally, both elements are of similar length, although there is some variability in this parameter (see measurements).

m3 (Fig. 6E): The third lower molar has a trigonid wider than the talonid. In this element, the talonid is not reduced to a single-cusped elevation, but it preserves a closed and elongated basin. As in the other two molars, the basal labial cingulid protrudes the occlusal outline under the paralophid.

Mandible (Fig. 6D, E): The horizontal ramus

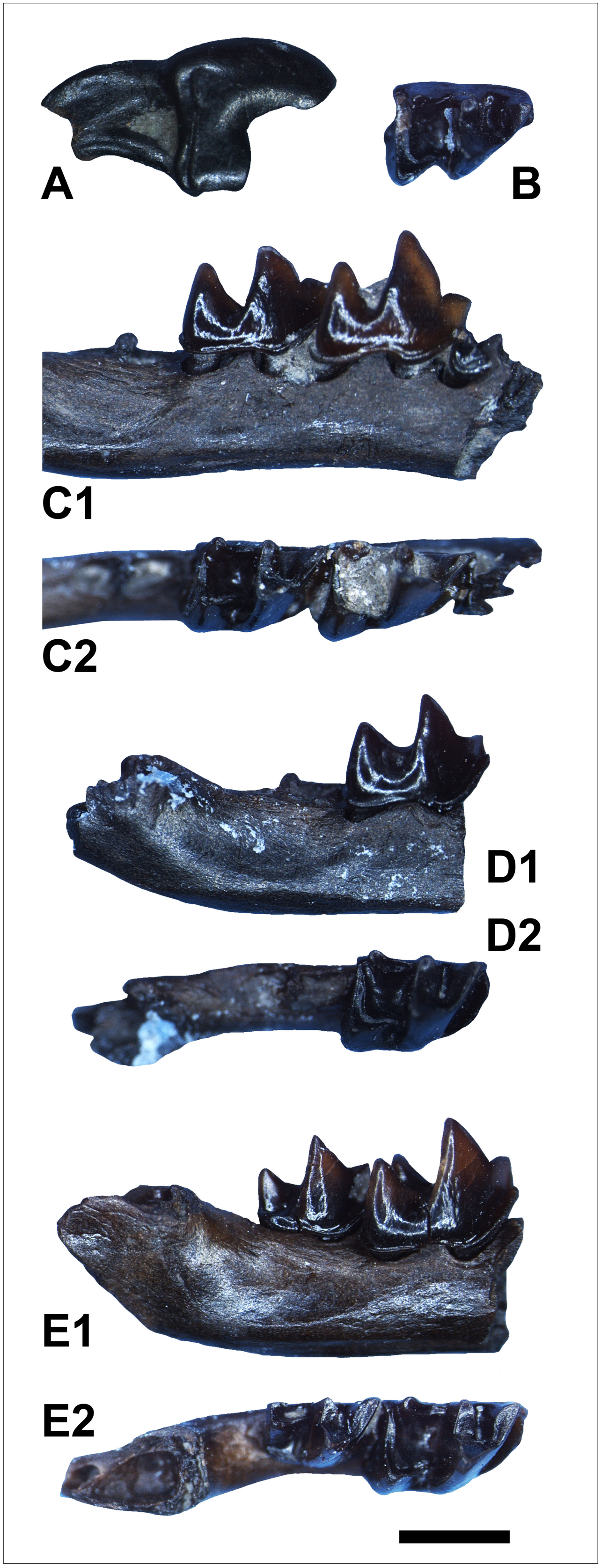

Fig. 6 - cf. *Lartetium* sp. from FdF2013. A) upper right incisor (IGF102256) in labial view; B) isolated right m1 (IGF102257) in occlusal view; C) right fragment of mandible with m1 and m2 (IGF102258) in labial (1) and occlusal (2) views; D) right fragment of mandible with m2 (IGF102259) in labial (1) and occlusal (2) views; E) right fragment of mandible with with m2 - m3 (IGF102260) in labial (1) and occlusal (2) views. Scale bars = 1 mm.

Collection number	element	H	L	TRW	TAW	W
IGF102256	I1	1.51	-	-	-	-
IGF102257	m1	-	1.38	0.90	1.07	-
IGF102258	m1	-	1.47	0.82	0.96	-
IGF102258	m2	-	1.45	0.88	0.88	-
IGF102259	m2	-	1.36	0.90	0.92	-
IGF102260	m2	-	1.50	0.93	0.93	-
IGF102260	m3	-	1.09	-	-	0.73

Tab. 1 - Measurements (in mm) of cf. *Lartetium* sp. from FdF2013.

has a rather faint aspect, with a soft undulation at its lower edge. The mental foramen is not visible under any molar, so it must have been placed below the premolar row, likely under the anterior half of the p4. It is not possible to discern how many alveoli were present anterior to the p4.

Remarks. The position of the mental foramen, not under the m1 but more advanced, is indicative of the subfamily Crocidosoricinae. Other than the African records, the last well-documented occurrences of crocidosoricines are found in the Vallesian (late Miocene) from Europe (Furió et al. 2007). Therefore, the presence of a crocidosoricine in the FdF2013 sample is in principle unexpected, postdating those youngest known occurrences with 1 my (at minimum). However, the occurrence of a 'crocidosoricinae-like' shrew had been already noticed by B. Engesser in Baccinello V1, quoting it as Soricidae, cf. *Crocidosorex* (Rook et al. 1996).

Unfortunately, the soricid material available from FdF2013 does not preserve sufficient diagnostical traits to provide a more detailed and sound taxonomic identification. In principle, the most simple hypothesis seems that a stock of crocidosoricine shrews remained isolated since (at least) the Vallesian in the Tusco-Sardinian region, thus surviving longer than their continental counterparts. Due to morphological and biostratigraphical reasons, the genera *Miosorex* and *Lartetium* are the most suitable candidates to be the origin of this relict population.

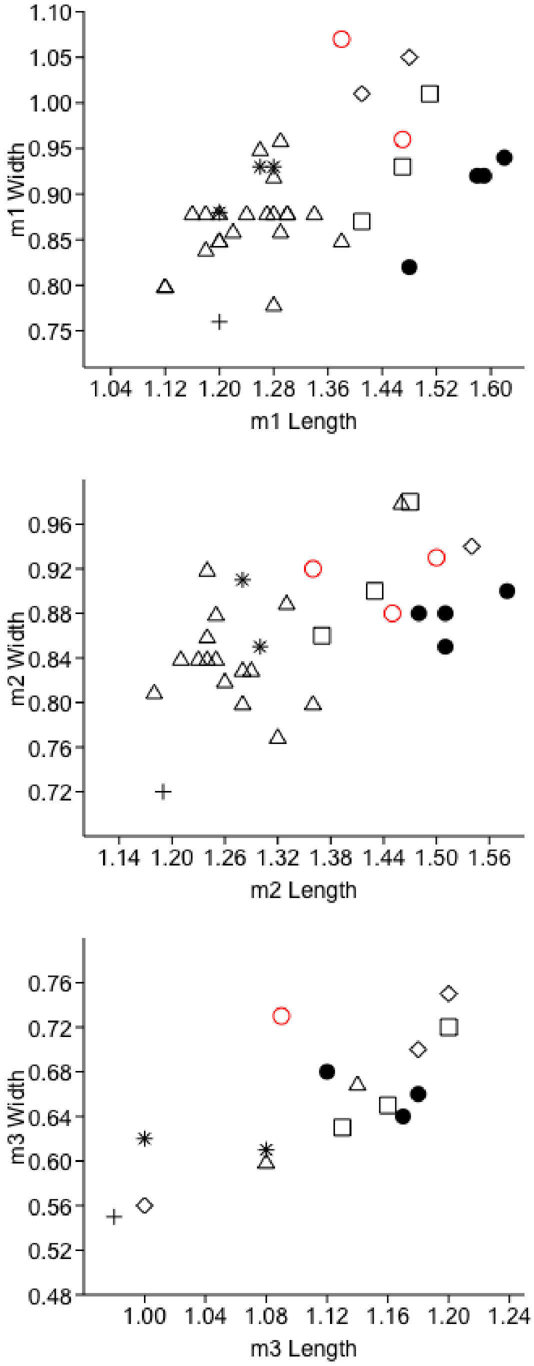

Fig. 7 - Scatter diagrams for m1, m2 and m3 Length / Width of different *Lartetium* species. Legend: open triangle, *L. prevostianum;* cross, *L.* cf. *prevostianum;* solid dot, *L. petersbuchense;* open square, *L. ziegleri;* open diamond, *L. dehmi* ; asterisck, *L. africanum;* open circle, cf. *Lartetium* sp. from Fosso della Fittaia 2013.
Data from Engesser (2009), Hugueney et al. (2012, 2015), Klietmann et al. (2013), Mein & Ginsburg (2002), and Ziegler (1989). Species with no individual metrics available in literature are represented by their mean values and/or holotype measurements.

Engesser (2009) provided some criteria to separate the dental elements of *Lartetium prevostianum* and *Miosorex desnoyersianus* from the locality of Sansan. Some of these characters of the lower molars can be used as a first approach to discriminate the material from FdF2013 at the genus level. Three out of the only four differential criteria provided by Engesser (2009) which are discernible in the material from FdF2013 fit better the characters of *Lartetium* than those of

Miosorex (1- similar length of m1 and m2; 2- oblique cristid ending more labially in m1 than in m2, and; 3- mental foramen not below the posterior end of p4). However, it is worth noting that the two species compared by Engesser (2009) are much older, so other possibilities could exist. For these reasons, the soricid material from FdF2013 has only been tentatively ascribed to the genus *Lartetium*, using a 'cf.' quotation.

Considering the dimension and proportions (Tab. 1; Fig. 7), the material from FdF2013 is notably smaller than *Lartetium petersbuchense* described in Ziegler (1989) and Klietmann et al. (2013), and in a lesser degree, smaller than *L. ziegleri* described in Mein and Ginsburg (2002) and Hugueney et al. (2012). On the other hand, it is larger than *L. prevostianum* described in Engesser (2009) and *L.* cf. *prevostianum* described in Klietmann et al. (2013), and *L. africanum* described in Lavocat (1961) and Hugueney et al. (2015). The only species within the genus covering the range of sizes measured in the lower molars from FdF2013 sample is *L. dehmi* from Vieux-Collonges, according to the data provided by Hugueney et al. (2012).

If the ascription of this material to *Lartetium* is confirmed in the future with new - more complete - finds, an alternative origin for this stock of shrews arise, because this genus probably survived longer in North African lands than it did in Europe (Hugueney et al. 2015 and references therein).

Order **Lagomorpha** Brandt, 1855
Family Ochotonidae Thomas, 1897
Genus *Paludotona* Dawson, 1959

Paludotona sp.

Material: a single upper molariform tooth (IGF102261).

Description. The single upper molariform tooth represents an ochotonid with simplified morphology and is referred to the genus *Paludotona*.

Discussion. The genus *Paludotona* (with the species *P. etruria*) is an endemic ochotonid only known from the OZF sites of the Baccinello-Cinigiano basin (Dawson 1959; Hürzeler & Engesser 1976). Engesser (1989) reports the occurrence of *Paludotona* cf. *etruria* among the taxa identified within the Fosso della Fittaia, Baccinello V0 assemblage.

Order **Rodentia** Bowdich, 1821
Family Gliridae Muirhead, 1819
Subfamily Leithiinae Lydekker, 1896
Genus *Anthracoglis* Engesser, 1983

Anthracoglis marinoi Engesser, 1983

Figs 8A,B; Tab. 2

Material: four isolated cheek teeth; one M2 (IGF102262) and a lower molar series (m1-m3) belonging to a single individual (IGF102263).

Description. The molar crown is relatively high for a glirid. The wear surface is markedly concave and the labial border in the upper molars is higher than the lingual one, whereas the lower molars show the lingual border higher than the labial one. The accessory ridges are as wide as the main ridges. The roots are not preserved.

The M2 (Tab. 2; Fig. 8B) is wider than long and shows a rectangular outline. The bases of two labial roots and a strong and flattened lingual root can be distinguished. There are five main ridges: anteroloph, protoloph, anterior centroloph, metaloph and posteroloph. All the main ridges, except for the anterior centroloph merge with the endoloph, which is thick and straight. The lingual ends of the anteroloph, protoloph and anterior centroloph bend posteriorly, whereas the metaloph and posteroloph are straight. The paracone and metacone are the only cusps that can be distinguished. A small groove separates these lingual cusps from the anteroloph and the posteroloph, respectively. There are accessory ridges in all the synclines. The two anterior accessory ridges are short and situated labially. The third and fourth accessory ridges are longer and somewhat thinner. The third ridge presumably corresponds to the posterior centroloph. The lingual side of the molar is ornamented with small pits.

The three lower molars (Tab. 2; Fig. 8A) show a comparable wear and their contact facets match perfectly, indicating that they all belong to the same individual. The roots have not been preserved. The m1 and m2 show a similar morphology, but can be

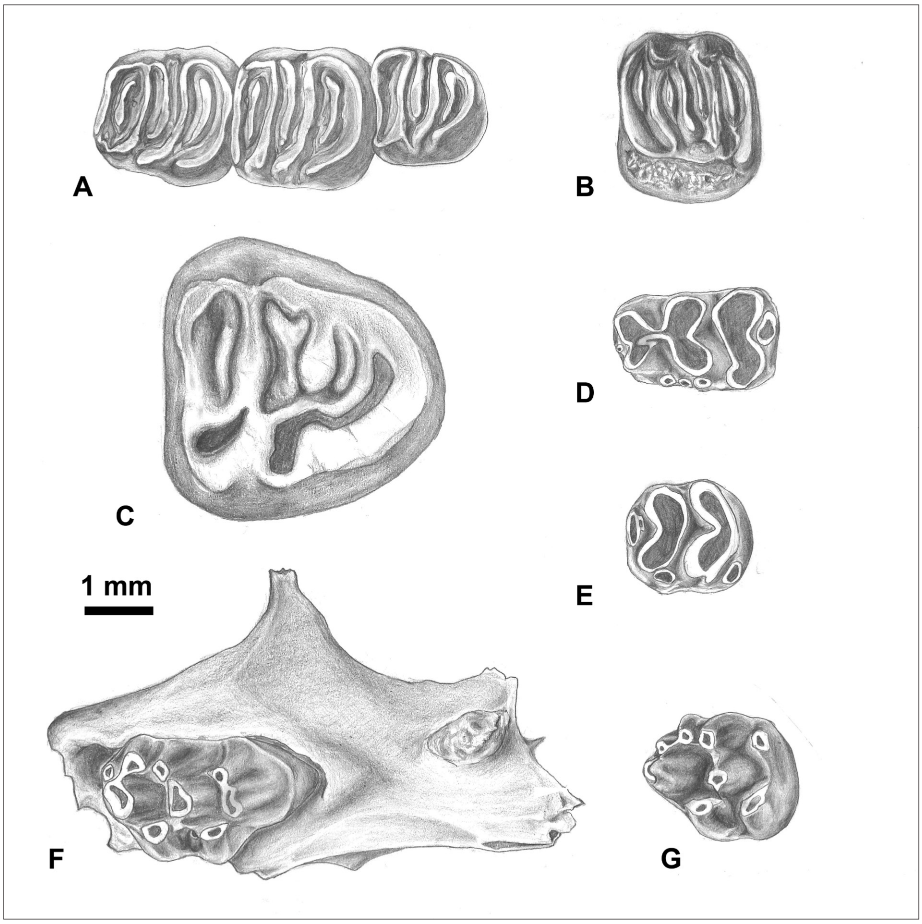

Fig. 8 - Gliridae and Muridae from FdF2013.
Anthracoglis marinoi: A) lower molar series (m1-m3) belonging to a single individual (IGF102263); B) M2 (IGF102262).
Gliridae new genus and new species: C) m3 (IGF102265).
Huerzelerimys oreopitheci: D) m1 (IGF102273); E) m2 (IGF102267); F) right maxillary with M1 (IGF102266); G) M2 (IGF102269).

clearly distinguished by the different shape of the m1, which is narrower in its anterior part. These molars show five main ridges that bend anteriorly in their labial ends: anterolophid, metalophid, centrolophid, mesolophid and posterolophid. The metalophid, mesolophid and posterolophid end labially in well-defined cusps, the protoconid, mesoconid and hypoconid, respectively. The anterior centrolophid is long, almost reaching the labial border of the molar. The endolophid is interrupted between the centrolophid and the mesolophid. The anterolophid and the metalophid connect labially, thus closing the first synclinid. There are long isolated accessory ridges in the first and last synclinids. The m3 is conspicuously reduced, but shows a similar morphology. The only differences are the absence of an anterior accessory ridge in the first synclinid and the weaker contact between the centrolophid and the endolophid.

Remarks. The measurements of the described specimens fit within the size range of *Anthracoglis marinoi* from Baccinello V1 (Engesser 1983), being clearly smaller than *A. engesseri* from Fiume Santo (Casanovas Vilar et al. 2011b). Quite remarkably, the m3 is very reduced. The occlusal morphology also fits with *A. marinoi*, although the accessory ridges are more reduced in the described specimens. The posterior centrolophid of the M2 is not connected to the metacone in IGF102262 and there are no other accessory ridges between the posterior centrolophid and the metalophid, in contrast to the holotype of *A. marinoi* (Engesser 1983). The m2 from Baccinello V1 may rarely show vestigial accessory ridges surrounding the centrolophid (Engesser 1983), whereas these are absent in the m2 described here. Finally, in contrast to the material described here, the single m3 from Baccinello 1 shows a continuous endolophid and an accessory ridge in the first synclinid (Engesser 1983). In the same specimen (Bac. 16; Engesser 1983: fig. 1), the endolophid is continuous and the centrolophid is not connected to it, whereas in the material from FdF2013 this ridge is connected to the endolophid which is interrupted immediately after it. The younger species *A. engesseri* shows more reduced accessory ridges than *A. marinoi* (Casanovas Vilar et al. 2011b), so the material may be ascribed to it. Nevertheless, the accessory ridges are not as reduced as in *A. engesseri* and

Collection number	element	L	W
Anthracoglis marinoi			
IGF102262	M2	2.02	2.33
IGF102263	m1	1.93	1.92
IGF102263	m2	2.01	1.99
IGF102263	m3	1.58	1.65
Gliridae gen. et sp. nov.			
IGF102264	M3	2.97	(3.46)
IGF102265	m3	3.56	3.59

Tab. 2 - Measurements (in mm) of *Anthracoglis marinoi* and Gliridae gen. et sp. nov. from FdF2013.

the size of the specimens is clearly smaller. Therefore, we assign the specimens to *A. marinoi*, noting that the development of accessory ridges can be quite variable in this species.

Gliridae gen. et sp. nov.

Fig. 8C; Tab. 2

Material: two isolated cheek teeth; one M3 (IGF102264), and one m3 (IGF102265).

Description. These two molars are clearly distinguished from those of *Anthracoglis marinoi* by their much larger size (Tab. 2) and simplified dental pattern consisting in fewer and considerably thicker ridges. The enamel is also thick and the occlusal surface only slightly concave. Both specimens are considerably worn, particularly the M3, which is furthermore damaged in its posterolingual part. The M3 presents three strong cylindrical roots, two in labial position and one in lingual position. The molar is so highly worn that the details of the occlusal morphology cannot be distinguished. However, the labial ends of at least four transverse ridges can be recognized. The anterior and posterior ridges were thicker than the two central ones. The m3 (Fig. 8C) is subtriangular. The roots have not been preserved, but the bases of two cylindrical anterior roots and a much larger posterior one can be distinguished. The molar morphology is relatively simple, with very narrow valleys that are closed both labially and lingually, as well as four thick transverse ridges merged by an equally thick continuous endolophid. We interpret those ridges as the anterolophid, metalophid, centrolophid and posterolophid. There are no accessory ridges. The anterolophid and metalophid are transverse and close a narrow anterior synclinid. The metalophid is constricted before reaching the metaconid. The endolophid is continuous with the posterolophid and the latter ridge merges with the mesoconid. The mesoconid and the protoconid are connected at this wear stage. The centrolophid is very short, just reaching the posterolophid, but without merging with it. On the labial side of the molar, wear has exposed the dentine in the protoconid; a longer stripe would correspond to the mesoconid and the hypoconid.

Remarks. Engesser (1983) described a single m3 of a gigantic dormouse from Baccinello V1 that agrees perfectly with the material described here. The morphology is roughly the same, even though the m3 described here is considerably more worn and the posterolophid merges with the mesoconid and the protoconid, so that all the valleys are closed labially. However, the specimen from Baccinello V1 is considerably larger (4.00 x 3.71 mm). Regarding the M3 reported here, it is so worn that the occlusal morphology is not preserved. Therefore, the specimens reported here are of little help in the description of this certainly new genus and species. Nonetheless, the characteristic morphology and large size allows the distinction of this glirid from all other genera, both insular and continental. Engesser (1983) noted similarities between this glirid and forms with simplified dental pattern such as *Peridyromys*. Unfortunately, the material is too scarce to provide further arguments to this regard. We hope that future campaigns at the Baccinello succession will provide further remains of this enigmatic taxon allowing the formal definition of a new genus and species.

Family Muridae Illiger, 1811
Genus *Huerzelerimys* Mein, Martín Suárez and Agustí, 1993

Huerzelerimys oreopitheci (Engesser, 1989)

Figs 8D-G; Tab. 3

Material: One maxillary fragment with an M1 (IGF102266), one fragmentary mandible with an m2 (IGF102267) and seven isolated cheek teeth: one M1 (IGF102268), four M2 (IGF102269, IGF102270, IGF102271, IGF102272), one m1 (IGF102273) and one broken m2 (IGF102274).

Description. The small maxillary fragment preserves the root.of the zygomatic and shows a well-developed and rounded masseteric tubercle

Collection number	element	L	W
IGF102266	M1	2.76	1.79
IGF102268	M1	2.69	1.90
IGF102269	M2	1.88	1.64
IGF102270	M2	1.81	1.78
IGF102271	M2	1.77	1.74
IGF102272	M2	1.98	1.79
IGF102273	m1	2.36	1.49
IGF102267	m2	1.75	1.56
IGF102274	m2	-	1.62

Tab. 3 - Measurements (in mm) of *Huerzelerimys oreopitheci* from FdF2013.

(Fig. 8F). The upper molar crowns are relatively high and the main cusps are inclined backwards. The M1 show five roots: a large anterior root under the t2; two lingual roots under the t1 and t4; a large posterior root under the t8-t9; and finally a small central root. The M1 (Fig. 8F) is relatively wide. The t1 is larger than the t3 and anteroposteriorly elongated. The t1 is placed more posteriorly than the t3. In one specimen (IGF102266; Fig. 8F) the t1 is connected to the t4 by the means of a very low ridge. In the other specimen (IGF102268) there is a cingular terrace on the anterior wall of the t2. The t4 is anteroposteriorly elongated and somewhat larger than the t6. The t6 and t9 are rounded and of roughly the same size; they are connected by a short ridge. There is no t7 and the t4 is connected to the t8 by a short and high ridge. The t9 is also connected to the t8. There is a small but conspicuous and rounded t12. The M2 (Fig. 8G) are short and wide. The roots are only preserved in three specimens (IGF102266, IGF102271, IGF102272), but these always show a total of five roots. There is a cylindrical root at each corner of the molar and a small root in central position. The morphology of the M2 resembles that of the M1, with the t8 being the larger and more prominent cusp and markedly inclined backwards. The t3 is placed opposite to the t1 and it is rounded and clearly smaller. There is a well-defined t6-t9-t8 connection. The t4 is connected to the t8 by a small ridge which is generally high. There is always a rounded t12, although it is less developed than in the m1.

The mandible is badly damaged, but some details can be observed. The mental foramen is placed quite dorsally and posteriorly. The diastema is apparently shallow. The lower masseteric ridge is prominent and ends up in a well-defined bulge situated under the anterior root of the m1. The upper masseteric ridge is faint. The recovered lower molars are relatively worn. The m1 (Fig. 8D) shows two large roots and is relatively short and wide. The protoconid-metaconid pair are separated from the hypoconid-entoconid pair by a deep valley. The antero-lingual cuspid is larger than the antero-labial one; the cuspids are fused and close to one another. The antero-lingual cuspid is connected to the metaconid by a short spur. There is a small antero-central cuspid. There are four rounded accessory cuspids on the buccal cingulid, with the posterior one being the largest. This accessory cuspid is completely fused with the hypoconid at this wear stage. The terminal heel is placed quite lingually. The m2 are rectangular and show two roots. They resemble the m1, but only present two accessory cuspids on the buccal cingulid. The posterior one is larger and placed just in front of the hypoconid. The anterior one is very small and partly fused with the protoconid. There is also a comma-shapped antero-labial cuspid.

Remarks. The described material fits within the size range of *Huerzelerimys oreopitheci* (Tab. 3; Fig. 9). This species is intermediate in size between its putative ancestor, *H. vireti*, and the morphologically similar *H. turoliensis* (Fig. 9). However, although it overlaps in size with the upper range of *H. vireti*, mean measurements are clearly larger. It further differs from *H. vireti* by the higher number of roots (five) in the M1 and M2. In *H. vireti,* the M1 shows three roots, although a minute fourth one may be present in some specimens, and the M2 may show three or four roots (Van de Weerd 1976; Martín-Suárez & Freudenthal 1993; Mein et al. 1993). Finally, the molars are more hypsodont and all the specimens show a t6-t9 connection, while this is variable in *H. vireti* (Van de Weerd 1976; Martin Suárez & Freudenthal 1993; Van Dam 1997). *Huerzelerimys turoliensis* is generally larger than *H. oreopitheci* (Fig. 9; see also Van de Weerd 1976; Martín-Suárez & Freudenthal, 1993; Van Dam, 1997) although it is morphologically similar. However, in the Baccinello form, the molars are more hypsodont and, although some M1 of *H. turoliensis* may show five roots (Martín Suárez & Freudenthal 1993), it is more common that the M1 and M2 have three to four roots. Furthermore, in

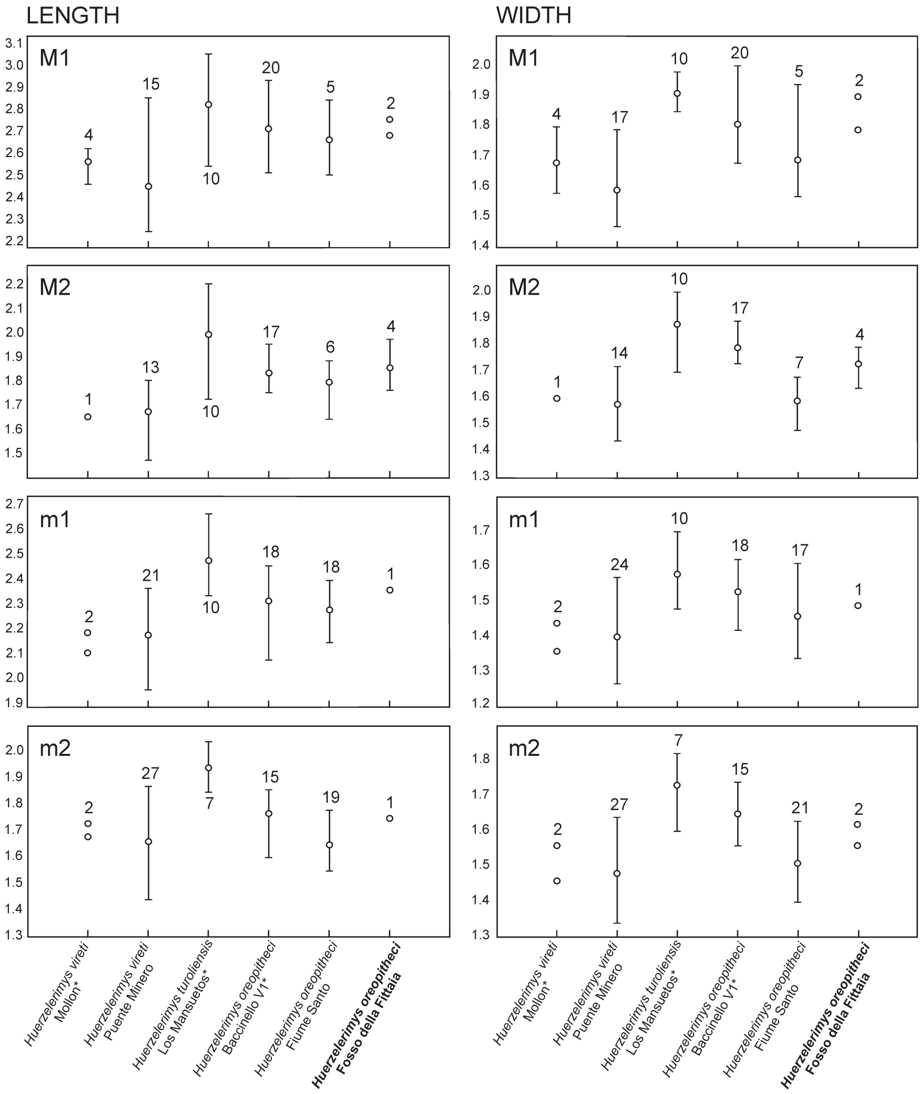

Fig. 9 - Length and width measurements for the first and second molars of different samples of *Huerzelerimys vireti, H. turoliensis* and *H. oreopitheci* as compared to the material from FdF2013. Only summary measurements are given: minimum, maximum and mean (open circle). The numbers next to each range plot indicate the number of specimens measured. In case less than three measurements are available, such as in the case of the Fosso della Fittaia 2013 sample, we provide discrete values. * indicates type locality for a given species.
Data sources: *H. vireti* from Mollon (Van de Weerd 1976); *H. vireti* from Puente Minero and *H. turoliensis* from Los Mansuetos (Van Dam 1997); *H. oreopitheci* from Baccinello V1 (Engesser 1989); *H. oreopitheci* from Fiume Santo (Casanovas Vilar et al. 2011b).

H. turoliensis, the t12 is reduced to just a widening of the ridge connecting the t8-t9, and this species commonly shows connections between t1 and t5 and between t3 and t5 in the M1 (Van de Weerd 1976; Van Dam 1997). Our material fits perfectly within the metrical and morphological range of *H. oreopitheci* from Baccinello V1 (Fig. 9; Engesser 1989) and Fiume Santo (Fig. 9; Casanovas Vilar et al. 2011b). The roots are not preserved in the Fiume Santo material, but the described specimens coincide in root number with the specimens from Baccinello V1. The t12 is present in all the recovered M1 and M2. This distinguishes the specimens from those from Fiume Santo, where the t12 is generally absent in the M2 (Casanovas Vilar et al. 2011b). In the material from Baccinello V1 the t12 of the M2 is apparently more reduced than in the material described here, but it is always present (Engesser 1989). Engesser (1989) introduced the *Huerzelerimys vireti – H. oreopitheci – Anthracomys lorenzi – A. majori* lineage. The members of this lineage would successively increase in size and hypsodonty and at the same time would simplify the molar pattern. This simplification implies the disappearance of the t12 in the M1 and M2, of the antero-central cuspid in the m1, and the reduction of accessory cuspids in the buccal cingulid of the lower molars. Although the material described here is scarce, the presence of t12 in all recovered upper molars and of antero-central cuspid in the only recovered m1, could be interpreted as an indication of an older age as compared to the material from Baccinello V1 and Fiume Santo, but still within zone V1.

Order **Artiodactyla** Owen, 1848
Family Bovidae Gray, 1821
Tribe Neotragini (Sclater and Thomas, 1894)

Genus *Tyrrhenotragus* Thomas, 1984

Tyrrhenotragus sp.

Material: one isolated lower cheek teeth m1 (or m2) (IGF102275).

Measurements (in mm) (L x W x H): 7.80 x 5.05 x 5.05.

Description. The single isolated lower molar is at an advanced stage of wear. It shows an undulating lingual wall, with well-developed parastylid.

Discussion. The genus *Tyrrhenotragus* (with the species *T. gracillimus*) is the smallest bovid species of the OZF faunal complex. According to Thomas (1984), dental and horn morphologies suggest that the genus is referable to the Neotragini tribe. It is present in both V1 and V2 assemblages from various sites of southern Tuscany (Baccinello, Casteani, Montebamboli, Ribolla) as well as in Sardinia at Fiume Santo (Abbazzi et al. 2008). Engesser (1989) mentions the occurrence of *Tyrrhenotragus* sp. among the taxa identified within the Fosso della Fittaia, Baccinello V0 assemblage.

DISCUSSION

The new vertebrate fauna from Fosso della Fittaia 2013 gives us the opportunity to better understand the biodiversity and the evolutionary patterns of the vertebrate faunas during the earliest phases of the BCB history. Noticeably the fauna includes the first freshwater fish record in the basin and a diverse herpetofauna, in addition to micromammals. The vertebrate assemblage fits quite well the depositional setting suggested from the deposits. The depositional evolution recorded in sub-unit CB1a ranges from footslopes evolving in marginal alluvial plain progressively affected by rise of the watertable. The latter may have created limited flooded areas in the final stage of deposition representing the habitat for the composite fauna collected in the FdF2013 sample including both terrestrial (tortoises, snakes, micromammals) and aquatic (e.g. fish, frogs) taxa.

Albeit represented by a single specimen, the freshwater fish record gives us some indications about the habitat of the earliest evolutionary stages of the BCB lake. Gobies occur in tropical and temperate regions showing a broad ecological radiation, with species occupying marine, brackish and freshwater habitats. Today, in the Mediterranean basin, freshwater gobies inhabit a variety of shallow water habitats with muddy, sandy and stony substrates (see Gandolfi et al. 1991). During the Tortonian-Messinian, the BCB underwent neither marine sedimentation nor minor marine influxes (due to its structural location East to the structural height known as "Mid-Tuscany Ridge"; Martini & Sagri 1993). The higher salinity of the water that from time to time characterizes the BCB (cfr. Ligios et al. 2008) can be explained as controlled by the dissolution of the calcareous anhydrite formations of Triassic age (which form the basement of southern Tuscany) and groundwater inflow of into the basin (Duchi et al. 1992; Benvenuti et al. 2004).

The herpetofauna is diverse, including possibly non-endemic anura (including a Discoglossinae indet.) and reptiles (lizards, snakes). The only endemic representative of the herpetofauna could be the tortoise, because it shows some similarities with *Testudo amiatae* Pantanelli, 1892 that was described from the Baccinello V3 assemblage of the BCB (Pantanelli 1892a, b), but its validity should be re-evaluated in the light of the recent redescription of *Testudo antiqua* Bronn, 1831 from the middle Miocene of Germany (Corsini et al. 2014). However, the presence of *Testudo* in the FdF2013 assemblage significantly extends the range of this taxon in the BCB: according to the results of Chesi et al. (2009), *Testudo* was restricted to the Baccinello V3 assemblage, whereas other chelonian taxa (*Mauremys* and trionychids) were present from the Baccinello V1 to the Baccinello V3 assemblage. The herpetofauna here described significantly improves the diversity of the BCB, even if it does not host the above-mentioned chelonians and the crocodilian reported for the Baccinello V1 and Baccinello V2 assemblages (Delfino & Rook 2008; Chesi et al. 2009).

Among mammals, most interesting is the presence of the insectivore cf. *Lartetium*. The identification of a crocidosoricine in the FdF2013 assemblage is in principle unexpected, since the subfamily went extinct during the Vallesian Crisis (Reumer 1987, 1994). Its presence in the FdF2013 assemblage postdates the youngest known Crocidosoricinae occurrences by 1 my (at minimum).

The rodent fauna consists exclusively of endemic taxa from the OZF: the glirid *Anthracoglis marinoi*, the murid *Huerzelerimys oreopitheci* and a yet unnamed gigantic glirid represented by just two teeth. This faunal assemblage includes the same species as Baccinello V1 except for the small murid *Parapodemus* sp., which was solely represented by a fragment of m1 or m2 (Engesser 1989). In Baccinello V0, the non-endemic murid *Huerzelerimys vireti* is recorded, whereas in V2, *Anthracoglis marinoi* is replaced by *Anthracoglis engesseri* and *Huerzelerimys oreopitheci* by the larger-sized murids *Anthracomys lorenzi* and *Anthracomys majori* (Engesser 1989). In the V2 site of Fiume Santo in Sardinia, *Huerzelerimys oreopitheci* coexists with *Anthracomys lorenzi* and *Anthracoglis engesseri* (Casanovas Vilar et al. 2011b).

Given the available data, we correlate the described FdF2013 fauna with zone V1. Such a conclusion agrees with the geological setting and magnetostratigraphic calibration. The Baccinello V0 assemblage, according to Engesser (1989, p. 233), lies seven meters below the lignite seam correlated with Baccinello V1. Our FdF2013 micorvertebrate fossil bearing level is higher in the series, being less than two meters below the superimposed massive lignite outcropping along the section at the junction of the Fittaia and Trasubbie creeks (Fig. 2). The presence of certain plesiomorphic features in *H. oreopitheci* indicates that the Baccinello V1 "classical" assemblage (cfr. Engesser 1989) is somewhat younger than FdF2013 one.

CONCLUSIONS

The late Miocene continental successions of the Baccinello-Cinigiano basin (Grosseto), one of the longest and most continuous vertebrate-bearing continental successions in the Neogene Italian record, yielded at least four superimposed vertebrate assemblages bracketed within a time span of 8.3 - 6.4 Ma. The oldest portion of the sedimentary succession has been here investigated in detail. The study allowed the recognition of a peculiar horizon of marly mudstone rich in land snails (Helicidae indet.), a terrestrial mollusc fauna not recognized in earlier studies and that we name here "F0" in according to the general basin scheme (Gillet et al. 1965; Lorenz 1968).

In addition, the vertebrate fauna within the BCB succession has been here better characterised, thanks to new findings of vertebrates along the Fosso della Fittaia.

The new vertebrate assemblage (FdF2013) includes a diverse herpetofauna and the first fish remains reported from the basin. Among mammals it is worth noting the occurrence of shrew remains (the first described from the basin) identified as cf. *Lartetium*. The latter attests the presence of a crocidosoricine in the FdF2013 fauna, postdating the youngest known occurrences of the subfamily by at least 1 my.

As far as rodents are concerned, in addition to the already recognized genera *Huerzelerimys* and *Anthracoglis*, a few dental remains are assigned to a new genus and species of giant dormouse which, due to the scarce material is not formally described. Finally a single fragment each, attest the occurrence of the endemic ochotonid *Paludotona* and artiodactyl *Thyrrenotragus*. On the other hand, our sample does not allow confirming the occurrence of Chiroptera in the oldest assemblages of the BCB as reported in faunal list based on NMHB samples (Kotsakis et al. 1997; Rook et al. 1996, 1999).

Our data allow us to correlate the described FdF2013 fauna with zone Baccinello V1 of the BCB biochronologic scheme. The assignment of the FdF2013 assembage to the Baccinello V1 zone confirms the correlation suggested by Lorenz (1968) of the lignites cropping out along the Trasubbie river with those exploited by mining activity in late 1950s that yielded the classical Baccinello V1 fauna.

Furthermore, the assignment of the FdF2013 fauna to the Baccinello V1 zone matches with the geological setting and magnetostratigraphic calibration of the sedimentary succession. Along the Fosso della Fittaia section, less than two meters separate the sandy clays that yielded the FdF2013 faunal assemblage from the superimposed massive lignite correlated with Baccinello V1, while the oldest assemblage described by Engesser (1989) as Baccinello V0 comes from a layer further five meters lower in the series (Fig. 2). Both the FdF2013 microvertebrate bearing layer and Baccinello V1 lignites are magnetostratigraphically referred to upper C4r (C4r.1r) chron, and thus likely dated to an age bracketed within the 8.3 and 8.1 Ma interval

(Rook et al. 2011). Even though this is the preferred correlation, an alternative correlation to the lower part of chron C4r (C4r.2r) is also possible (on the basis of biochronological constraints), and this would yield a somewhat older age for the Baccinello V0 and V1 faunas, closer to 8.7 Ma.

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