2008). The pes tracks show an elliptical shape and are larger than the associated *manus* tracks (sub-circular or sub-elliptical), showing a marked heteropody. The *manus-pes* distance is generally about 50 cm, even if sometimes the tracks overlap. The forelimb prints are outward rotated with respect to pes-long axis, with an angle ranging from 20° to 25° (Avanzini et al., 2008). In the best-preserved set, the *manus* is 15.5 cm long and 14 cm wide, whereas the *pes* is 64 cm long and 57 cm wide, showing an asymmetric morphology, narrower and deeper in the proximal area (Avanzini et al., 2008). After comparison with some narrow-gauge sauropod trackways from the Early Jurassic of Poland (Gierliński, 1997; Gierliński and Pieńkowski, 1999) and other large sauropod footprints from the Calcari Grigi (Avanzini et al., 2006), Avanzini et al. (2008) referred the Monte Finonchio tracks to the ichnogenus *Parabrontopodus*.

2.8. BECCO DI FILADONNA ICHNOSITE, VAL GOLA (TRENTINO-ALTO ADIGE, NORTHERN ITALY), LATE HETTANGIAN - EARLY SINEMURIAN

Avanzini (1997) described two distinct dinosaur track-bearing horizons, recognized on the slope of the Val Gola, a wide valley west of the Becco di Filadonna massif in the Province of Trento.

The track-bearing horizons are found in the Monte Zugna Formation. The first layer is represented by a dolomitized stromatolitic bindstone of the 'Middle Peritidal Unit'. The second horizon is located at the top of two stromatolitic levels, overlying bioturbated brown and dark grey wackestones to packstones: these deposits belong to the 'Upper Subtidal Unit' of Hettangian-early Sinemurian age (Avanzini, 1997; Avanzini et al., 2006; Avanzini and Petti, 2008).

The ichnoassemblage from Becco di Filadonna consists of isolated tridactyl tracks, assigned to medium-sized theropods, and large quadrupedal trackways, referred to medium-sized sauropods (Fig. 14) (Avanzini, 1997; Leonardi and Mietto, 2000; Avanzini and Petti, 2008).

The tridactyl tracks are not well preserved, but stout and deep digit impressions are clearly recognizable, suggesting a tentative ichnotaxonomic assignment to *Eubrontes* isp. (Avanzini, 1997; Leonardi and Mietto, 2000).

Likewise, the *manus-pes* couples, arranged in narrow-gauge trackways, show a poor preservation, without anatomical details (Avanzini and Petti, 2008). In the best-preserved tracks, the *manus* print is wider (FW=44 cm) than long (FL=32 cm) and shows an irregular outline, with three shallow impressions, interpreted as possible digit prints. The associated *pes* print, emphasized by large raised rims, is sub-elliptical, deeper in its proximal portion and longer (FL=75 cm) than wide (FW=50 cm) (Avanzini, 1997; Leonardi and Mietto, 2000). The

Fig. 13 - The steep surface of the Monte Finonchio ichnosite where faintly visible quadrupedal footprints are preserved.

narrow-gauge arrangement of the trackways suggests an assignment of these quadrupedal footprints to the ichnogenus *Parabrontopodus* (Avanzini, 1997; Avanzini and Petti, 2008).

2.9. BELLA LASTA ICHNOSITE, LESSINI MOUNTAINS (VENETO, NORTHERN ITALY), LATE SINEMURIAN

Mietto et al. (2000) analysed several dinosaur tracks from the 'Bella Lasta' site (Province of Verona), located on the western slope of the Revolto Valley, between Passo Malera and Cima Trappola (Lessini Mountains).

Five track layers have been recognized in a 8.5 m thick stratigraphic succession, near the boundary between the Loppio Oolitic Limestone and the Rotzo Formation (Mietto and Roghi, 1993; Roghi, 1994; Mietto et al., 2000; Avanzini and Petti, 2008).

The lower track-bearing interval (layers VRBL 20, 25, 1 and 5) is 70 cm thick. It is characterized by oolitic grainstone (oolitic bars), produced by tidal currents in shallow marine environments and early cemented by endolithic algae, while the upper interval (layers VRBL 2, 3 and 4) is a wackestone with pyrite nodules, suggesting a lagoonal palaeoenvironment (Mietto et al., 2000).

These deposits are covered by a 10 cm thick slightly terrigenous limestone, with abundant bivalves and gastropods (Mietto et al., 2000; Avanzini and Petti, 2008). The age of the track-bearing interval is late Sinemurian (Avanzini and Petti, 2008).

Fig. 14 - Sauropodomorph tracks of the Becco di Filadonna ichnosite (Val Gola, Trento; scale bar 30 cm).

So far as the ichnological record reported by Mietto et al. (2000) is concerned, only two morphotypes have been identified. The first, comprising only two well-preserved successive footprints, is tridactyl, with tracks about 31.5 cm long and 28 cm wide (Fig. 15; Pl. 3, fig. b). The high total divarication angle between digits II and IV suggested to Mietto et al. (2000) to assign these tridactyl tracks to the ichnogenus *Kayentapus*. The second morphotype is represented by irregular *manus-pes* sets left by a quadrupedal trackmaker. The *pes* print is sub-circular and wider than long (FL=21 cm; FW=30 cm). The associated *manus* is sub-circular, 17 cm long and 14 cm wide. Mietto et al. (2000) noticed an affinity of the Bella Lasta quadrupedal specimen with some tracks from the Lavini di Marco site referred to sauropods. Nevertheless, due to the significantly different shape of the *manus* print of the Bella Lasta quadrupedal track, with respect to sauropod forelimb tracks, the analysed specimen was just tentatively referred to a sauropod or prosauropod trackmaker (Mietto et al., 2000).

By order of the Soprintendenza Archeologica del Veneto, in 2001 the two tridactyl footprints were removed by the staff of the Civic Museum of Natural History of Verona. These ichnites are currently on exhibit at the Geopaleontological Museum of Camposilvano (Velo Veronese, Verona).

2.10. STOL DEI CAMPILUZZI ICHNOSITE, MONTE PASUBIO (TRENTINO-ALTO ADIGE, NORTHERN ITALY), LATE SINEMURIAN

Petti et al. (2011a) reported the occurrence of three dinosaur tracks in the Stol dei Campiluzzi tunnel, dug by the Austro-Hungarian and Italian armies during the First World War. The tunnel is located below the Campiluzzi saddle, west of Monte Buso, in the Monte Pasubio massif (Trentino-Alto Adige); it is about 250 m long, 2.5 m wide and 2 m high (Petti et al., 2011a).

The stratigraphic section of the Stol dei Campiluzzi has a thickness of 19 m. At the base it is composed of massive oolitic grainstone, 80 cm thick, marked by low-angle cross laminations: these deposits belong to the Loppio Oolitic Limestone, and are overlain by a reddish surface, interpreted as evidence of subaerial exposure. The overlying Rotzo Formation starts with a 13 m thick interval composed of well-stratified, grey to yellow limestone-marl alternations. The deposits are characterized by the occurrence, in various layers, of: i) wackestone to packstone with intraclasts and bioclasts; ii) four black shale levels with bivalves (*Eomiodon* sp. and *Lithioperna* sp.). The dinosaur track-bearing horizons are located between the second and the third level rich in organic matter. Thin-bedded and nodular limestones (5 m thick), showing invertebrate burrows (*Thalassinoides* isp.), are found at the top of the section. The age of the

Fig. 15 - A theropod track from Bella Lasta ichnosite (Lessini Mountains, Verona; scale bar 10 cm).

dinosaur tracks is considered as late Sinemurian (Petti et al., 2011a).

The vertebrate track record is composed of three mesaxonic and functionally tridactyl tracks preserved on the roof of the tunnel (Fig. 16; Pl. 3, fig. c) as convex hyporeliefs *sensu* Leonardi (1987), and likely produced by medium-sized theropods. Footprint length is in the range 25-26 cm, by a width of about 22-24 cm. Mesaxony is weak (te about 8 cm), while total divarication angle is relatively high at values in the range 57°-64°.

Following Thulborn (1990) and Weems (2006), Petti et al. (2011a) estimated for the trackmaker a hip height of 1.25 m, a body length of 5 m and a body mass of 206 kg. The morphological analogies and the statistical affinities (FL/te ratio, according to Weems, 1992) with the coeval tridactyl tracks from Poland (Gierliński et al., 2004), allowed the authors to assign the Stol dei Campiluzzi tracks to *Kayentapus* isp.

2.11. MAROCCHE DI DRO ICHNOSITE, SARCA VALLEY (TRENTINO-ALTO ADIGE, NORTHERN ITALY), LATE SINEMURIAN - PLIENSBACHIAN

Avanzini et al. (2001b) analysed some track-bearing limestone blocks in the Marocche di Dro landslides, about 2 km north of Drena in the Sarca Valley (Trentino-Alto Adige).

The boulders are composed of light-grey to yellowish grey packstone, characterised by the occurrence of oolites, bioclasts, algal lumps, pellets, dasycladacean algae, and lituolid and miliolinid foraminifera (Avanzini et al., 2001b; Avanzini and Petti, 2008). A subtidal palaeoenvironment was suggested, with mud banks and sand deposits, constituted by oolitic bars, occurring close together. The dinosaur tracks are filled with the same sediment as the substrate, separated from the track-bearing surface by laminae of red clay. The blocks were assigned to the upper part of the Calcari Grigi Group (Tovel Member of the Rotzo Formation *sensu* Castellarin et al., 2005), deposited during the late Sinemurian to Pliensbachian (Avanzini et al., 2001b; Avanzini and Petti, 2008).

Within the ichnoassemblage, several tracks were identified, some of which were grouped into three trackways (Fig. 17; Pl. 2, fig. g). Among these, two display sub-elliptical *pes* prints about 25 cm in diameter associated to ellipsoidal *manus* prints wider than long (FL=16 cm and FW=20 cm on average). A low heteropody is clearly recognizable: the quadrupedal trackmaker had a stout forelimb, with a *manus* slightly smaller than the *pes* (Avanzini et al., 2001b). Four stubby digits are recognizable in at least one of the footprints. The morphological features of these trackways rule out sauropods and prosauropods as possible trackmakers. The tracks share some morphological affinity with those referred to the Ankylosauridae, such as the ichnogenera *Metatetrapodus* and *Tetrapodosaurus* (McCrea et al., 2001; Hornung and Reich, 2014). A small-sized basal thyreophoran, such as *Scelidosaurus* from the Early Jurassic of England, was assumed as the most likely trackmaker (Avanzini et al., 2001b; Avanzini and Petti, 2008).

The third trackway, preserved on the surface of another quadrangular block, is characterised by four *manus-pes* couples. The *pes* prints are elliptical, elongated and asymmetrical with respect to the axis (FL=30 cm; FW=20.7 cm, on average). The forelimb prints are sub-circular and smaller than the associated hindlimb print (FL=14.2 cm; FW=13.5 cm, on average). This trackway strongly differs from the two discussed above: the morphological and morphometrical analysis suggests a best fit with a prosauropod trackmaker (Avanzini et al., 2001b; Avanzini and Petti, 2008).

2.12. COSTE DELL'ANGLONE ICHNOSITE, MONTE BRENTO (TRENTINO-ALTO ADIGE, NORTHERN ITALY), LATE SINEMURIAN - PLIENSBACHIAN

Petti et al. (2011b) described hundreds of dinosaur tracks, originally reported by Avanzini et al. (2007), from the wide monoclinal surface of Coste dell'Anglone, located on the eastern slope of the Mt. Biaina-Mt. Brento ridge (Dro, Trentino-Alto Adige), a few kilometres north of the Garda Lake.

The track-bearing horizon belongs to a stratigraphic succession characterised by shallowing-upward cycles. Each cycle is characterised by the transition from a low energy subtidal unit (intensely bioturbated

Fig. 16 - Theropod tracks preserved as natural casts on the roof of Stol dei Campiluzzi tunnel, dug during the First World War; scale bar 10 cm.

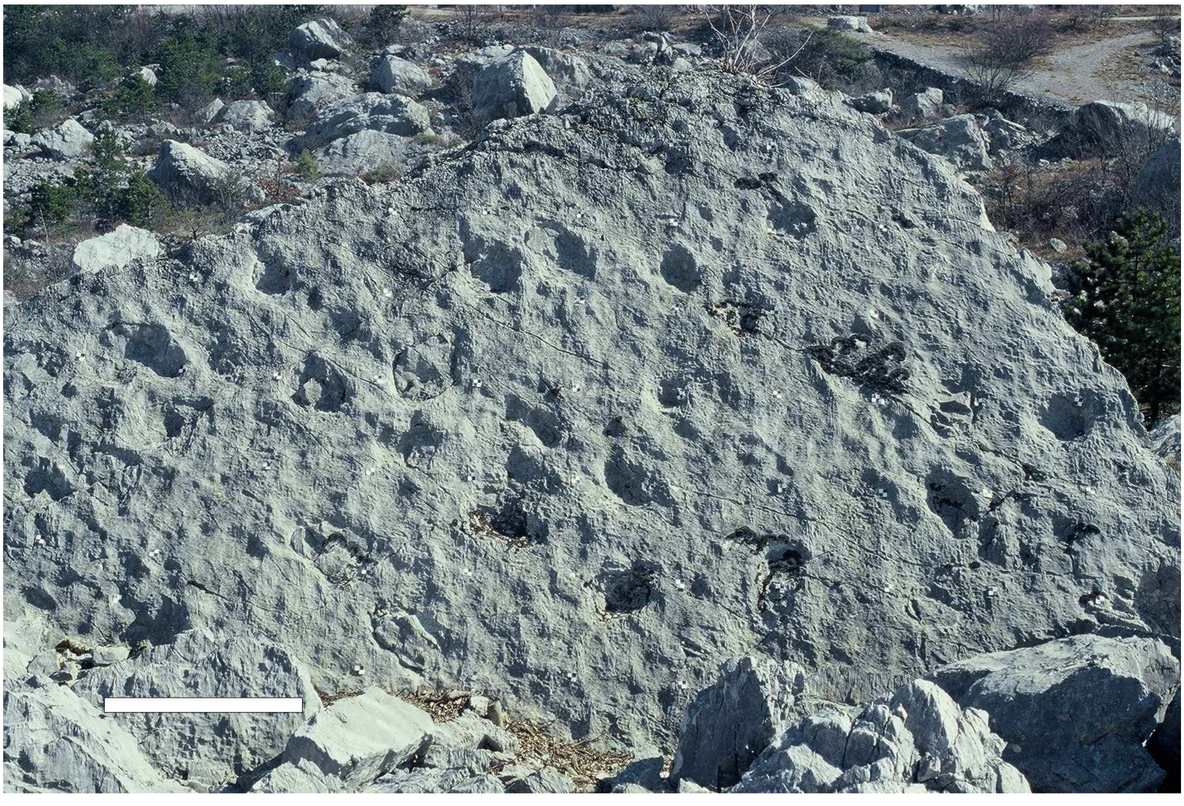

Fig. 17 - Basal thyreophoran trackway at Marocche di Dro tracksite (Trento, Sinemurian-Pliensbachian); scale bar 1 m.

nodular limestone), with associated invertebrate traces (*Thalassinoides* isp., *Chondrites* isp.), to high energy subtidal deposits (oolitic grainstone with intraclasts and bioclasts) up into inter- and supra-tidal deposits (Petti et al., 2011b).

In the upper part of the sequence, the track layer consists of poorly fossiliferous dark grey stromatolitic and peloidal mudstone (Avanzini and Petti, 2008; Petti et al., 2011b). The section belongs to the lowermost portion of the Rotzo Formation (formerly Tovel Member *sensu* Castellarin et al., 2005) and the microfossil assemblages indicate a late Sinemurian to Pliensbachian age (Avanzini and Petti, 2008; Petti et al., 2011b).

The Coste dell'Anglone tracksite probably represents the last dinosaur occurrence on the Trento Platform. The ichnological record is represented by 544 tridactyl footprints arranged in 20 trackways (Fig. 18), left by bipedal trackmakers and mainly oriented between ESE and SSE (Petti et al., 2011b). The tracksite was investigated using both traditional study methods and modern techniques, such as close-range photogrammetry and laser scanner, to gain more objective morphological details for the ichnotaxonomical analysis (Petti et al., 2008a; Pl. 3, fig. d).

The dinosaur footprints, preserved as concave epirelief (*sensu* Leonardi, 1987), are mesaxonic, functionally tridactyl and asymmetric. The best-preserved tracks are small to medium-sized, slightly longer than wide (14.5 cm ≤FL ≤ 26 cm; 12.7 cm ≤ FW ≤ 20 cm); te is moderate (Pl. 3, figs. d,e). The digits appear similar and slender, with sharp claw marks at the end. The total divarication between digits II and IV ranges between 48° and 70°. The footprints form a typical narrow-gauge trackway, with pace angulation ranging between 170° and 180°. The high morphological variation that can be observed among the tracks mainly results from local changes in the physical properties of the substrate covered by a microbial mat. Nevertheless, all tracks were probably produced by individuals with the same functional anatomy of the hind foot (Petti et al., 2011b). The tracks show morphologies similar to some specimens assigned to the ichnogenera *Kayentapus* and *Anchisauripus* and mainly distributed in North America (Irby, 1995) and Northern Europe (Gierliński et al., 2004; Gierliński and Niedźwiedzki, 2005). Analysis of the morphometrical parameters suggests assigning the Coste dell'Anglone footprints and trackways to *Kayentapus* isp. (Petti et al., 2011b) and attributing them to small to medium-sized theropods.

3. PALAEOECOLOGY OF THE EARLY JURASSIC DINOSAUR MEGATRACKSITES FROM THE SOUTHERN ALPS

All the described ichnosites from the Trento Platform can be grouped into four main dinosaur megatracksites (Leonardi and Mietto, 2000; Avanzini et al., 2006). Their track fossils occur in carbonate units once thought to be totally marine in origin and constitute the most extensive Early Jurassic dinosaur tracksites among those currently known in Europe (Lockley and Meyer, 2000). The older megatracksite spans multiple horizons in the middle part of the lower Hettangian Monte Zugna Formation of the Calcari Grigi Group. The second megatracksite occurs near the top of the Monte Zugna Fm. and is of early Sinemurian age. The third one is preserved at the top of the Oolite di Loppio Formation which is Sinemurian in age. The youngest megatracksite occurs at the base of Rotzo Formation, late Sinemurian-early Pliensbachian in age.

The first level corresponds to several important supratidal intervals of exposure of a wide tidal flat. The second is represented by two intertidal, stromatolitic levels recognizable across the whole Trento Platform. The third level is located at the top of the Loppio Oolite and corresponds to an important regional unconformity. The fourth level corresponds to a marked sea level fall and is related to a complex regional palaeogeographic scenario, with brackish ponds and subtidal channels recognizable across the whole Trento Platform.

Avanzini et al. (2006) carried out a quantitative palynological analysis of samples from the footprint-bearing horizons, in order to reconstruct the plant assemblages of the ecosystem in which the dinosaurs lived. The predominant palynomorphs are *Azonotriletes* spores belonging to pteridophytes, bisaccate and circumpolles grains belonging to conifers, *Chasmatosporites* pertaining

Fig. 18 - Theropod trackways of the Coste dell'Anglone ichnosite (Trento, late Sinemurian-Pliensbachian; F.M. Petti for scale).

to the Cycadales, and *Eucommiidites* of uncertain affinity. In the lower samples, circumpolles dominates the flora (80%) and indicate a subtropical, warm, and rather arid climate. Upsection, an increment of spores (*Azonotriletes* group) typical of humid environments indicates a climate change as well as freshwater influence. Palynomorphs suggest therefore the constant presence of conifers belonging to the Cheirolepidiaceae (circumpolles), arborescent plants living in coastal environments (Avanzini et al., 2006).

The vertebrate ichnofauna of the studied track levels is a typical, dinosaur-dominated (and saurischian-dominated), Early Jurassic tetrapod assemblage characterized by the presence of theropod footprints such as *Eubrontes, Kayentapus, Anchisauripus* and *Grallator*. This typical track assemblage includes sauropodomorph (*Parabrontopodus* and *Otozoum*-like tracks such as *Lavinipes*), crocodylomorph, and synapsid (*Brasilichnium* Leonardi, 1981) footprints.

Theropods dominate in the Hettangian megatracksite level 1, whereas megatracksite levels 2 and 3, both Sinemurian, are dominated by sauropodomorph tracks. Theropods dominate in megatracksite level 4, late Sinemurian to early Pliensbachian in age. The inversion in predominance between theropod and sauropodomorph tracks between levels 1 and 2-3 coincides both with a change in regional floras, as corroborated by palynomorphs, and sedimentological data indicating an environmental shift from arid to humid conditions between megatracksites 1 and 2-3. From these data, it follows that the Early Jurassic dinosaur faunas of the Southern Alps were controlled by the environmental and climatic variations of this palaeogeographic region across the Hettangian-Sinemurian boundary. Large Sinemurian sauropodomorphs that preferred humid tidal flats replaced the small sauropodomorphs of arid Hettangian tidal flats. Theropods that were dominant in the arid Hettangian tidal flats became subordinate to sauropods in this region during the Sinemurian. In the late Sinemurian the complex local palaeogeography reduces the presence of sauropods and despite the ever more humid conditions theropods become again the most widely represented group. *Kayentapus* is the most widespread ichnotaxon among the above-described ichnosites. Its tentative attribution to ceratosaurian dinosaurs, such as *Dilophosaurus* from the Early Jurassic of Arizona (USA), suggests a possible geographical connection between the Southern Alps sector and the southern margin of the Laurasian mainland (North America and Europe) up to the Sinemurian (Petti et al., 2011b).

4. EARLY JURASSIC MARINE REPTILE TRACKS

4.1. BURANO RIVER ICHNOSITE (MARCHE, CENTRAL ITALY), LATE PLIENSBACHIAN

Manni et al. (2000) described an unusual tetrapod trackway from the Upper Pliensbachian pelagic deposits of the Corniola Formation. The track-bearing surface was found by the late B. Accordi in the early 1980's along the Burano River, between the villages of Cantiano and Cagli (Marche, Central Italy); it was later removed and is now deposited in the collections of the Museo Universitario di Scienze della Terra (MUST) of SAPIENZA University. In order to constrain its stratigraphic position, Manni et al. (2000) performed a bed-by-bed sampling collecting several ammonite specimens that indicate the upper *A. algovianum* Zone or the basal *E. emaciatum* Zone (late Pliensbachian). The trackway, named *Accordiichnus natans*, is 3.13 m long and about 50 cm wide and is composed of two rows of pear-shaped impressions (22 imprints) and by a sinuous central row made by 21 groups of centimetre-sized oval impressions. Each group is composed of five impressions connecting two consecutive pear-shaped imprints. Manni et al. (2000) attributed this trackway to an unknown marine reptile swimming near the sea-bottom. They interpreted the pear-shaped imprints as the *manus* impression, whereas the five separate imprints would represent the pes. This interpretation has been questioned by Seilacher (1997, 2007), who proposed other hypotheses, such as "burrow system or large plants with regular branching" or a giant "asterosomid burrow system". It is noteworthy that in 1994 some poorly-preserved tracks, closely matching those described by Manni et al. (2000), were found on a track-bearing surface at Palareto, near Cantiano (Arduini, 1996). Also this horizon belongs to the Corniola Formation and can be ascribed to the early Pliensbachian (Manni et al., 2000). The tracks were interpreted by Arduini (1996) as undertracks of sauropodomorphs, but, being the Corniola Formation a pelagic unit, this hypothesis must be discarded. As reported by Manni et al. (2000) an attribution to a marine reptile is more likely.

5. SUPPOSED LATE JURASSIC FOOTPRINTS FROM ITALY

5.1. MATTINATA ICHNOSITE, GARGANO (PUGLIA, SOUTHERN ITALY)

Conti et al. (2005) reported the find of three closely associated dolomitized limestone blocks with dinosaur footprints on a small pier near the town of Mattinata on the Gargano Promontory, Province of Foggia. The pier was constructed during the 1960s with material derived from the western Gargano quarrying district, where Upper Jurassic to Upper Cretaceous carbonates crop out. Although today all active quarries are set within the Upper Cretaceous San Giovanni Rotondo Limestone, there has been quarrying in the underlying Sannicandro Formation in the mid-20th century, so both formations can be considered as possible sources of the Mattinata blocks. According to Bosellini et al. (1999, 2001), the Sannicandro Formation was deposited in a time interval from at least the Callovian to the early Valanginian, whereas the Calcare di Bari Formation (formerly San Giovanni Rotondo Limestone) was formed in the late Valanginian-early Aptian interval. Based mainly on their lithological features, the blocks were referred to the peritidal facies of the Sannicandro Formation and assigned a Kimmeridgian-Tithonian age. Although some uncertainty remains about this age assignment (L. Spalluto, pers. comm.), the Mattinata footprints are, at present, the only dinosaur ichnological record in non-Alpine Italy tentatively referred to the Jurassic, and as yet the only possibly Late Jurassic tracks recorded from Italy.

The sedimentological study of the blocks revealed a complex texture ranging from brecciated intervals to well-laminated beds probably produced by microbial mats; the dinosaur footprints themselves are impressed on a surface that shows evidence of such a microbial mat. The footprints are preserved as concave epirelief on two of the blocks (named MPA and MPC) and as convex hyporelief on the third one (MPB). Together, the three blocks preserve 37 dinosaur footprints. All are tridactyl and mesaxonic, in a size range around 30 cm (footprint length without metatarsal impression). Conti et al. (2005) discuss only the best-preserved footprints (17 out of 37) and divide the assemblage into three morphotypes. Morphotype 1 tracks (Fig. 19A) are the most abundant (12 out of 17) and are characterized by displaying a short hallux impression, sometimes associated with a partial imprint of the metatarsus; digits II-IV are slender with sharply pointed tips. Morphotype 2 tracks (Fig. 19B), represented by three specimens, are characterised by stout digits, no hallux or metatarsal impression, and rather low divarication angles if compared with type 1. Morphotype 3 tracks (two specimens only) resemble morphotype 1 in having a wider divarication angle but are similar to morphotype 2 in having stout digits and lacking hallux and metatarsus impression. The choice of dividing the ichnoassemblage into morphotypes instead of applying ichnotaxonomic names leaves the possibility open that the observed differences may be related to preservational factors, rather than to different trackmakers. In any case, mid-sized theropod trackmakers are inferred for all the footprints, and the possibility is discussed that morphotype 1 tracks may be assigned to the ichnogenus *Theroplantigrada*, an ichnotaxon based on Aptian dinosaur tracks from La Rioja.

At the time of their discovery, the Mattinata footprints were one of only three finds of dinosaur footprints on the Apulian carbonate platform, the other two being the Early Cretaceous site of Borgo Celano (Gianolla et al., 2000; Petti et al., 2008b) and the Late Cretaceous site of Altamura (Nicosia et al., 2000). Since then, a number of new tracksites, all Early Cretaceous in age, have been discovered from this palaeogeographic domain (see Petti et al., 2020, for an updated review in this issue). The occurrence of abundant dinosaur tracks at different stratigraphical levels within the Apulian carbonate platform triggered a rediscussion of established palaeogeographical models, which is still continuing (Bosellini, 2002; Conti et al., 2005; Petti, 2006; Nicosia et al., 2007; Zarcone et al., 2010; Citton et al., 2015). The Jurassic tracksites of Italy thus become part of a wider context; they have proved to be useful sources of information that give us a glimpse into the biodiversity, ecology and palaeogeography of a long-lost world.

6. CONCLUDING REMARKS

The discovery of several dinosaur tracksites in Trentino Alto-Adige and Veneto has triggered a review of the palaeobiological, palaeoclimatic and palaeogeographic framework of the Southern Alps sector during the Jurassic. The dinosaur tracks occur in four distinct and laterally continuous horizons ("megatracksites") within the Calcari Grigi Group. The analysis of the faunal

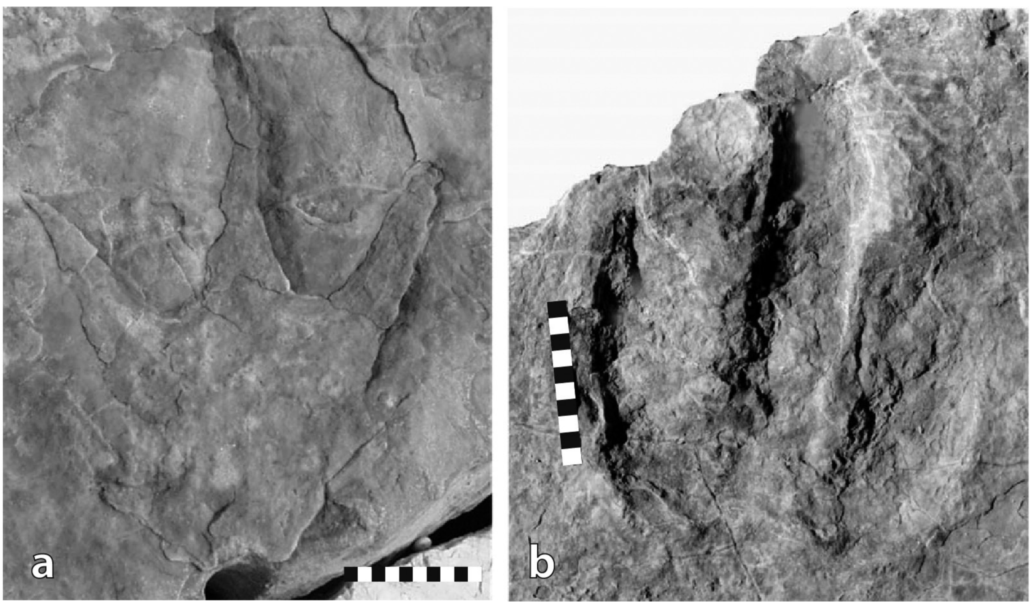

Fig. 19 - Tetradactyl (a) and tridactyl theropod tracks (b) of the Mattinata ichnosite (Gargano Promontory, Kimmeridgian-Tithonian, scale bar 10 cm).

composition indicates significant differences among them, suggesting an environmental shift from arid to humid conditions between the Hettangian and the Sinemurian.

Additionally, the dinosaur ichnological record of the Trento carbonate platform provides clues on the palaeogeography of the South Alpine sector during the Jurassic. The palaeobiological constraints provided by the dinosaur ichnoassemblages suggest a connection between the Laurasian mainland and the Southern Alps during the Early Jurassic.

The Mesozoic tectonic evolution of the Southern Alps sector thus explains the lack of dinosaur tracks in Northern Italy since the Toarcian.

The occurrence of possibly Late Jurassic dinosaur tracks in Apulia (Mattinata tracksite) stresses the need for a review of the palaeogeographic evolution of the Periadriatic sector during the Mesozoic, based on the palaeontological constraints provided by the abundance of dinosaur ichnosites in this region.

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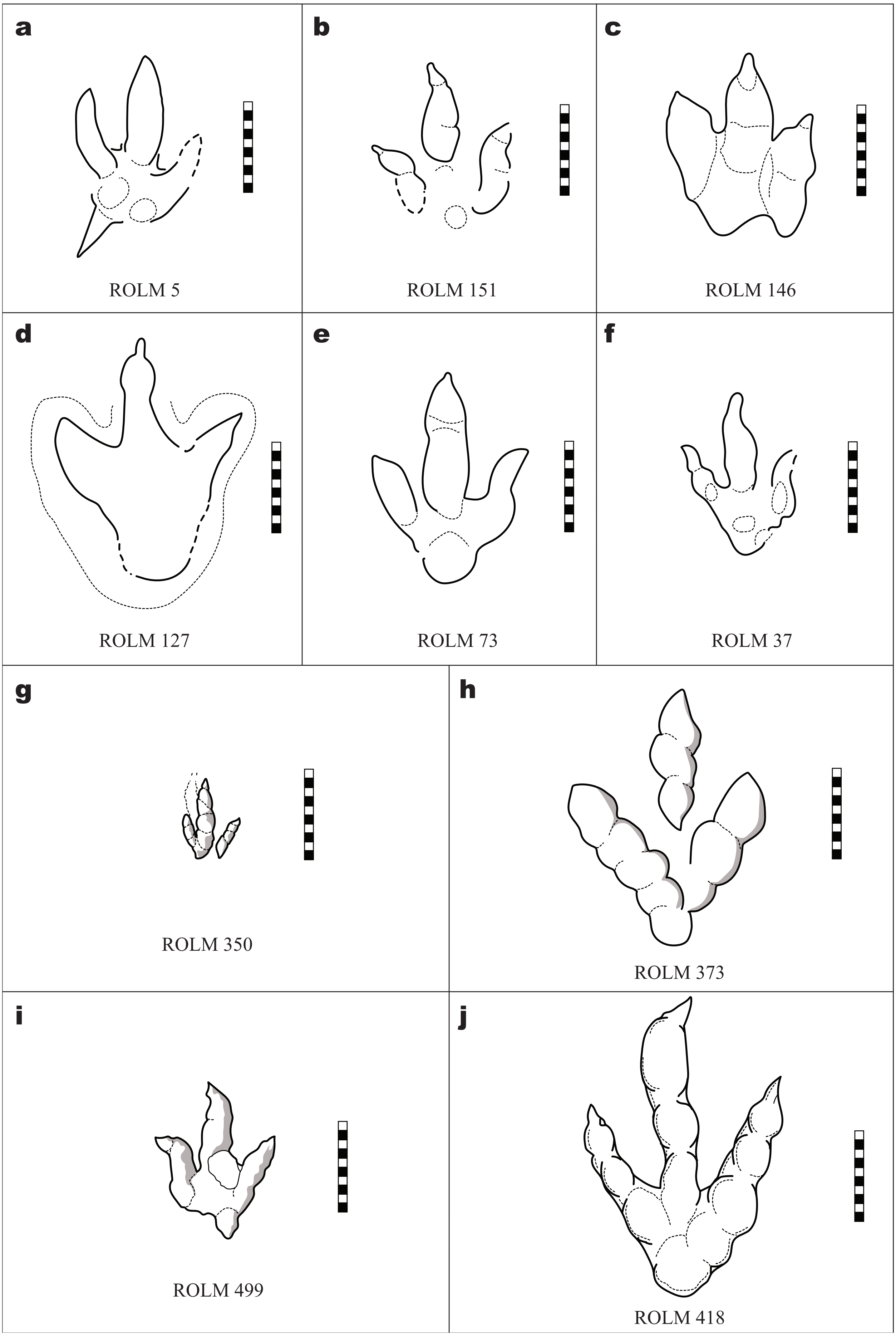
PLATES


a
ROLM 5
b
ROLM 151
c
ROLM 146
d
ROLM 127
e
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f
ROLM 37
g
ROLM 350
h
ROLM 373
i
ROLM 499
j
ROLM 418

Plate 1 - Theropod tracks from the Lavini di Marco tracksite (Hettangian - Trentino-Alto Adige, Northern Italy). a) specimen ROLM 5, representative of the first morphotype of Leonardi and Mietto (2000). b) specimen ROLM 151, representative of the second morphotype of Leonardi and Mietto (2000). c) specimen ROLM 146 representative of the third morphotype of Leonardi and Mietto (2000). d) specimen ROLM 127, representative of the fourth morphotype of Leonardi and Mietto (2000). e) specimen ROLM 73, representative of the fifth morphotype of Leonardi and Mietto (2000). f) specimen ROLM 37, representative of the sixth morphotype of Leonardi and Mietto (2000). g) specimen ROLM 350, representative of the morphotype LA1 of Piubelli (2006). h) specimen ROLM 373, representative of the morphotype LA2 of Piubelli (2006). i) specimen ROLM 499, representing the morphotype LA3 of Piubelli (2006). j) specimen ROLM 418, representative of the morphotype LA4 of Piubelli (2006). Scale bars = 10 cm. Specimens are redrawn from Leonardi and Mietto (2000) and Piubelli (2006).

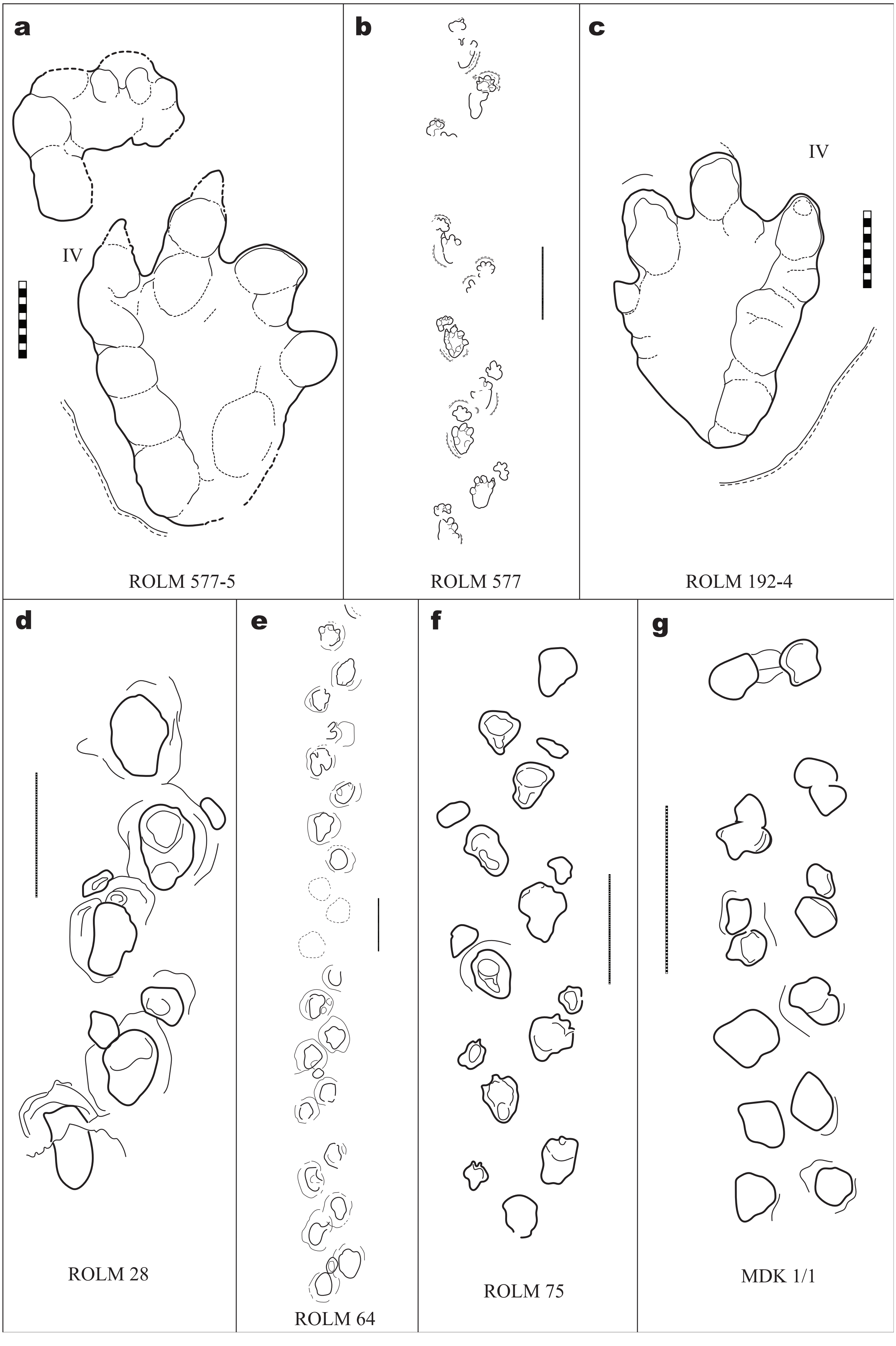
a
IV
ROLM 577-5
b
ROLM 577
c
IV
ROLM 192-4
d
ROLM 28
e
ROLM 64
f
ROLM 75
g
MDK 1/1

Plate 2 - Tracks and trackways attributed to herbivorous dinosaurs from the Lavini di Marco (a-f; Hettangian - Trentino-Alto Adige, Northern Italy) and Marocche di Dro tracksites (g; late Sinemurian - Pliensbachian; Trentino-Alto Adige, Northern Italy. a) ROLM 577-5 *manus-pes* set, holotype of *Lavinipes cheminii*; scale bar = 10 cm. b) ROLM 577 trackway; scale bar = 1 m. c) ROLM 192-4 *manus-pes* set, paratype of *Lavinipes cheminii*; scale bar = 10 cm. d) ROLM 28 trackway (*Parabrontopodus* isp); scale bar = 1 m. e) ROLM 64 trackway, formerly referred to a possible ornithopod trackmaker; scale bar = 1 m. f) ROLM 75 trackway (*Parabrontopodus* isp.); scale bar = 1 m. g) MDK 1/1 trackway, morphologically similar to ichnogenera *Metatetrapodus* and *Tetrapodosaurus* and referred to basal thyreophoran; scale bar = 1 m. Specimens are redrawn from Leonardi and Mietto (2000), Avanzini et al. (2003) and Avanzini and Petti (2008).

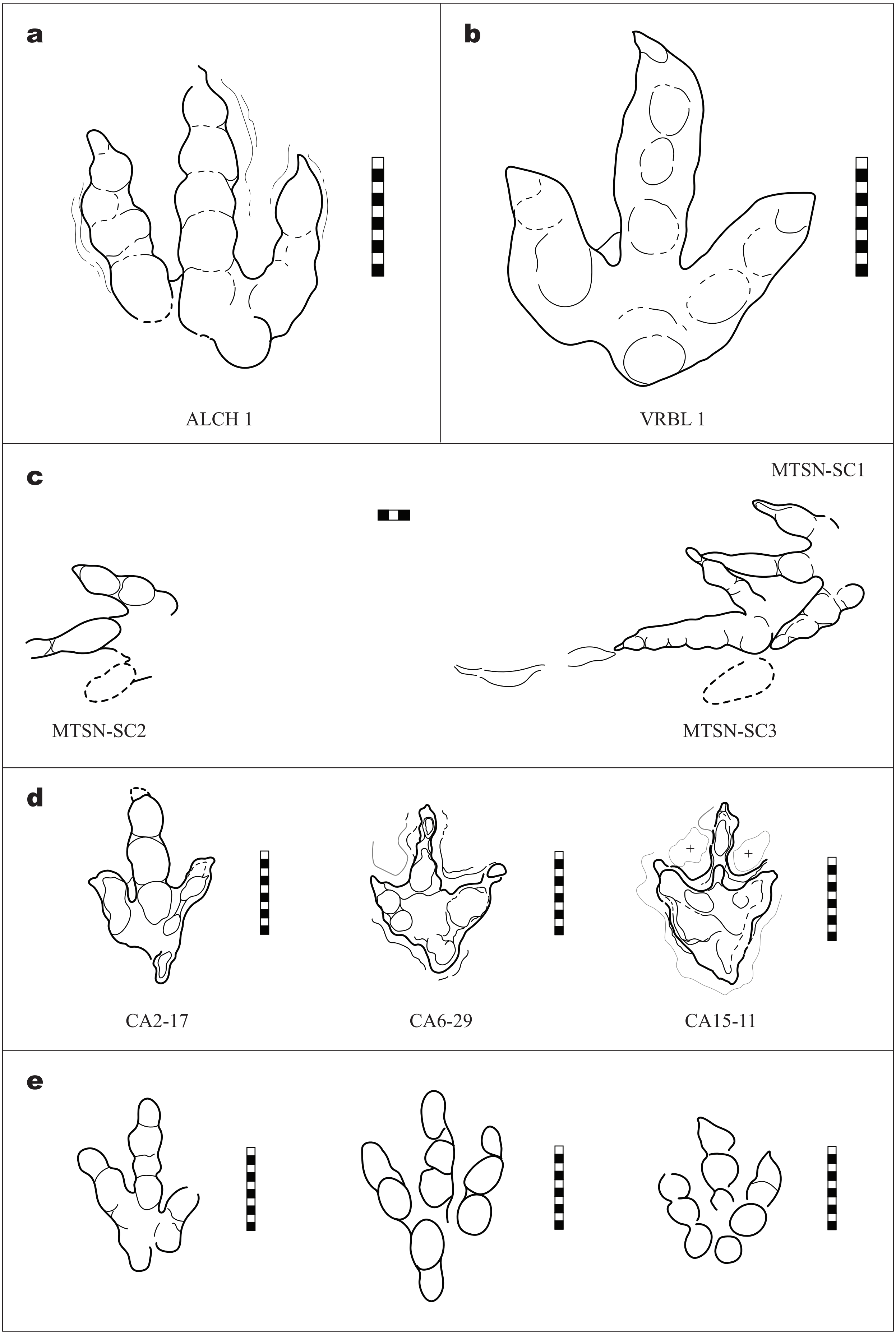
a
ALCH 1
b
VRBL 1
c
MTSN-SC1
MTSN-SC2
MTSN-SC3
d
CA2-17
CA6-29
CA15-11
e

Plate 3 - Theropod tracks from other ichnosites belonging to the Calcari Grigi Group (Lower Jurassic, Southern Alps). a) specimen ALCH 1 (*Kayentapus* isp.) from the Chizzola tracksite. b) specimen VRBL 1 (*Kayentapus* isp.) from the Bella Lasta tracksite. c) medium-sized tridactyl tracks (*Kayentapus* isp.) from the Stol dei Campiluzzi tracksite. d) medium-sized tridactyl tracks from the Coste dell'Anglone tracksite (specimens CA2-17, CA6-29 and CA15-11). e) unnamed medium-sized tridactyl tracks from the Coste dell'Anglone tracksite. Scale bars = 10 cm. Interpretative sketches are redrawn from Avanzini and Petti (2008), Petti et al. (2011a, 2011b).