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TETRAPOD FOOTPRINTS FROM THE MESOZOIC CARBONATE PLATFORMS OF THE ITALIAN ALPS*

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RESUMEN

Está documentado que hay fósiles de tetrápodos en los Alpes italianos desde el Carbonífero superior al Cretácico - excepto durante la parte alta del Jurásico (Dogger-Malm). En los sedimentos del Triásico medio hay abundantes huellas de vertebrados de los que son bien conocidas las de grandes arcosaurios quiroterioides y de lepidosauromorfos pequeños. Dentro de estas asociaciones icníticas hay huellas dinosauromorfas de pies tridáctilos funcionales. En el Carniense la icnofauna muestra diversidad de biomasa, probablemente de afinidad gondwánica. En este conjunto algunas especies se pueden atribuir a dinosaurios primitivos cuyos pies son tridáctilos funcionales, probablemente prosaurópodos cuadrúpedos o semibípedos. Durante el Carniense superior las huellas son de dinosaurios verdaderos que coexisten con los últimos arcosaurios basales. Hay pisadas aisladas que se atribuyen a terópodos grandes y medianos, mientras que las marcas bípedas se suponen de ornitópodos basales y de prosaurópodos ligeros. El paso entre el Triásico y el Jurásico se nota porque desaparecen las huellas atribuibles a quiroterios y por la abundancia de huellas de dinosaurios.

Palabras clave: Pisadas de arcosaurios, Pisadas de dinosaurios, Triásico, Jurásico. Norte de Italia.

ABSTRACT

In the Italian Alps, the presence of tetrapods is documented from the Late Carboniferous to the Cretaceous with an interruption in correspondence with the Late

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Jurassic (Dogger-Malm). The traces of vertebrate are well represented in the sediments of the middle Triassic in which large chirotheriid archosaurs and smaller lepidosauromorpha tracks are documented. Among these ichnoassociations there are some specimens with functionally tridactyl dinosauromorph pes. In the Carnian the ichnofauna shows a diversified biomass, probably of gondwanic affinity. In this assemblage some specimens can be probably attributed to primitive dinosaurs with functionally tridactyl feet as well as possible quadruped or semi-biped prosauropods. In the Late Carnian the prints reveal the existence of an association in which true dinosaurs coexisted alongside the last basal Archosaurs. Isolated tridactyl footprints are attributed mostly to medium to large theropod dinosaurs, whereas some bipedal tracks are probably referable to basal ornithischia and light – bodied prosauropods. The passage between the Triassic and the Jurassic is characterised by the disappearance of Chirotherium -like footprints and the massive appearance of dinosaur footprints.

Key words: Archosaur footprints; dinosaur footprints; Triassic; Jurassic; Northern Italy.

In the Italian eastern alpine region are recognisable well-exposed sections in which marine sediments and continental deposits rich in footprints are interfirgered. These mixed sections enabled us to build a framework of biostratigraphic and chronological data in which tetrapod footprint layers can be related to an evolutional sequence (Avanzini *et al.* 2000a; 2000b; Avanzini *et al.* 2001a).

In the Italian Alps, the presence of tetrapods is documented from the Late Carboniferous to the Cretaceous with an interruption in correspondence with the Late Jurassic (Dogger-Malm).

Isolated footprints attributed to *Limnopus* sp. and *Hylopus* cf. *Hylopus hardingi* Dawson come from the Upper Carboniferous of Carnia in the eastern Alps.

The Lower Permian ichnological record comes from the Collio Formation of Eastern Lombardy (Val Trompia and Orobian basin) and Western Trentino (Tregiovo). This ichnofauna is composed of *Antichnium salamandroides, Camunipes cassinisi, Dromopus lacertoides, Dromopus didactylus, Amphisauropus latus, Ichniotherium cottae, Anhomoichnium orobicum*, and an unidentified amphibian and lacertoid ichnotaxon (Conti *et al.*, 2000). They belong to two small amphibian taxa, a relatively large plant-eating reptile and six small reptilian taxa. Temnospondylian amphibians, Captorhinida, Araeoscelida, Lepidosauromorpha, Pelicosauria and perhaps Diadectidae are represented.

A peculiar and very important Late Permian ichnofauna is that of the continental (fluvial) Val Gardena Sandstone of NE Italy, dated to 255-265 m.y.a (Changxingian-Djulfian). Footprints have been found mainly in the provinces of Bolzano/Bozen and Trento but specimens also come from the environs of Recoaro (Vicenza) and from Carnia region (Udine). All footprints belong to reptiles: large plant-eaters such as Pareiasaurs (*Pachypes dolomiticus*), mid-sized plant-eaters like pelicosaurian Caseids, large predators like the Gorgonopsians and possibly also primitive Archosaurs (the oldest chirotheroid footprints) and small predators like the primitive Cynodonts (*Dicynodontipus*). Small lacertoid reptiles are represented by *Hyloidichnus tirolensis, Paradoxichnium, Rhynchosauroides* (which are very common), *Janusichnium* and footprints attributed to Procolophonomorpha (Avanzini *et al.*, 2001a; Conti *et al.*, 2000).

The traces of vertebrates diminish during the Lower Triassic, when only the ichnogenera *Rynchosauroides* is documented (Mietto, 1986). The traces of vertebrate are instead, well represented in the continental or marginal marine of the early middle Triassic (Anisian). Overall there is mainly evidence of reptilian fauna, in which large Archosaurs and smaller reptiles are documented. Chirotheriids and lepidosauromorpha tracks typically dominate this ichnofauna. In particular, *Chirotherium* Kaup 1835, *Parachirotherium* Kuhn 1958, *Brachichirotherium* Beurlen 1950, *Isochirotherium* Haubold 1971, *Rotodactylus* Peabody 1948, *Parasynaptichnium* Mietto 1987, *Synaptichnium* Nopcsa 1923 and *Rhyncosauroides* Maidwell 1911 ichnogenera have been recognised (Abel, 1926; Brandner, 1973; Mietto, 1987; Sirna *et al.*, 1994; Avanzini and Neri, 1998; Avanzini, 1999; Avanzini, 2000; Conti *et al.*, 2000; Avanzini *et al.*, 2001a; 2001b; Avanzini and Leonardi, 2002, Avanzini and Lockley, 2002; Avanzini and Renesto, 2002). Among these ichnoassociatons there are some specimens with functionally tridactyl dinosauromorph pes dated closer to Late Pelsonian – Early Illyrian boundary (Avanzini, 2002a) (Fig. 1).

The tetrapods disappear from the South - Eastern Alps between the late Anisian and Ladinian (in correspondence of a great transgression) and for all the Ladinian up to the Lower Carnian the eastern South Alpine sector has a paleogeography that is characterised by basins and isolated carbonate platforms, with a Southern area that is the source of clastic material located in the position of today's Po Valley. In the Middle Carnian (limits Julian/Tuvalian) the bordered carbonate platforms disappear completely and are replaced by ramps carbonate sedimentation (Gianolla *et al.*, 1998; Avanzini *et al.* 2000a). From this moment on the tetrapods reappear. The ichnofauna has a diversified biomass, probably of gondwanic affinity (Leonardi and Mietto, 2000), which assumes its origins from a large southern land, bordered by mostly emerged carbonate platforms.

The oldest of these associations is that from the lagoon peritidal facies of the Cassian Dolomites of the most southern area of the Dolomites (Avanzini *et al.*, in prep.) (Fig.2). The age is referable to the *Austriacum* Zone (upper Julian) based on the ammonites collected in the related basinal sediments of the S. Cassiano Fm. (Avanzini *et al.* 2000a). In this assemblage, reptilian prints that can be attributed to *Chirotherium* sp. and cfr. *Apatopus* were found. Some specimens, can be probably attributed to primitive dinosaurs with functionally tridactyl feet as well as possible quadruped or semi-biped prosauropods (cfr. *Tetrasauropus*).

Close to the Julian/Tuvalian boundary most of the Dolomites went through a short humid climatic event that interrupted the monotony of the dry climate of the Upper Triassic. This event is testified to by a clastic lithozone with a fluvial coastal environment (intercalated with the Dürrenstein Formation) in which there are abundant plant remains (conifers, ferns, horsetails, Benettitales) and amber (Gianolla *et al.*, 1998b), which are joined by paleosoils originated in humid environments.

In these environments vertebrates were abundant (Sirna *et al.* 1994; Bizzarini and Rottonara 1997). Fish are represented by the dipnoan *Ceratodus* sp. (Bizzarini and Rottonara, 1997), possibly by the paleonisciform Birgeria and by hybodontoid sharks. A complete skull and lower jaw and some specimens represent the temnospondylian amphibian *Metoposaurus santaecrucis* Koken 1913. Coastal reptiles are represented by the scattered bones of sauropterygians (Sirna *et al.*, 1994). Also "thecodontian" teeth are reported and attributed to Rauisuchia by Bizzarini and Rottonara (1997) while maxillary or middle-posterior mandibular teeth of phytosaurs have recently been described by Dalla Vecchia and Avanzini (2002). The ichnoassociations confirm the presence of Archosaurs (*Chirotherium* sp.) which

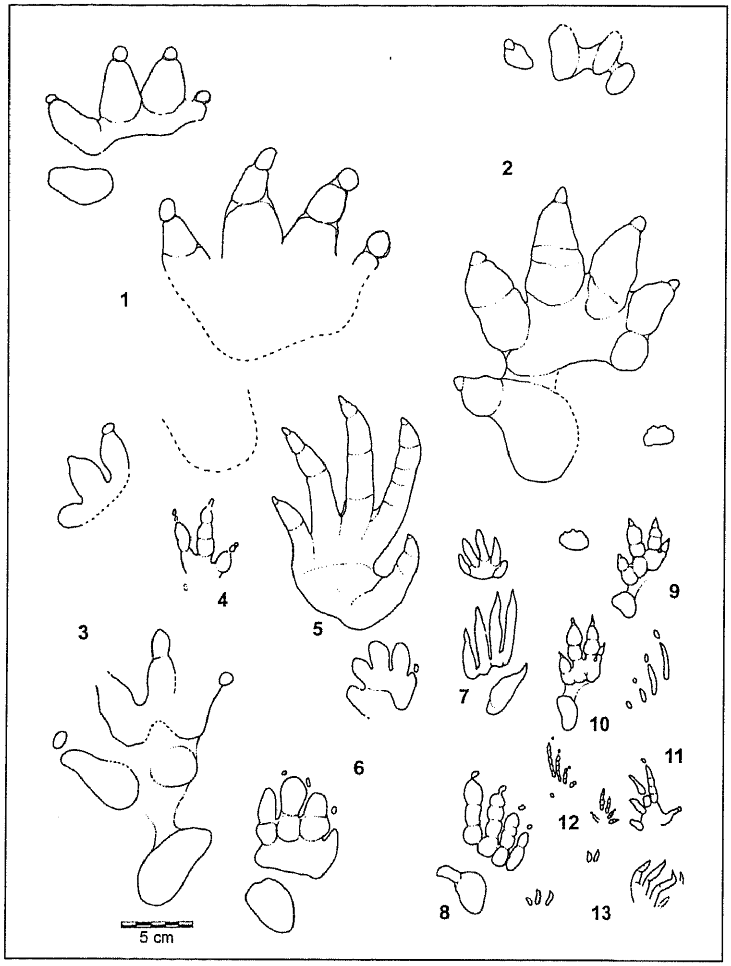

FIGURE 1. ***Early (13) and Middle (1-12) Triassic footprints from Dolomites and surrounding areas (same scale: 5 cm). 1:*** Chirotherium ***cf.*** C. rex ***Peabody 1948, redrawn from Brandner (1973), Anisian. 2:*** Isochirotherium inferni ***Avanzini and Leonardi 2002, redrawn from Avanzini and Leonardi (2002), Anisian. 3:*** Parachirotherium ***sp. (BzBGI/40), redrawn from Avanzini et al. (2001), Anisian. 4: Unnamed tridactyl dinosauromorph footprint (ULFIW46), redrawn from Avanzini (2002), Anisian. 5:*** Parasynaptichnium gracilis ***Mietto 1987, redrawn from Mietto (1987), Anisian. 6:*** Brachychirotherium ***aff. B.*** parvum ***Hitchcock 1889, redrawn from Brandner (1973), Anisian. 7:*** Synaptichnium pseudosucoides ***Nopcsa, 1923, Anisian. 8:*** Synaptichnium cameronense ***Peabody 1948, Anisian. 9-10:*** Isochiroterium delicatum ***Courel and Demathieu 1976 robust and slender forms, redrawn from Avanzini and Lockley (2002), Anisian. 11-12:*** Rhynchosauroides tirolicus, ***Abel 1923, redrawn from Avanzini and Renesto (2002), Anisian. 13:*** Rhynchosauroides schocardti ***Rühle von Lilestern 1939, redrawn from Mietto (1986), Scythian.***

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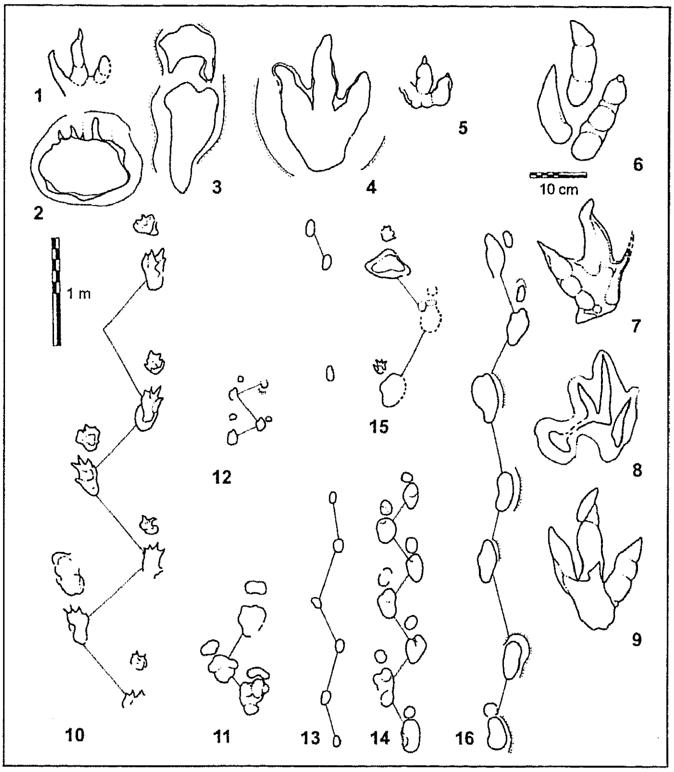

FIGURE 2. ***Late Triassic footprints from Eastern Southern Alps (Dolomites and Carnia) (1-9 same scale: 10 cm; 10-16 same scale: 1 m). 1: unnamed tridactyl footprint, Val Badia, Carnian. 2: ?terapsid footprint, Val Badia, Carnian. 3: chirotheroid manus-pes couple, Val Badia, Carnian. 4: unnamed tridacty footprint, Tre Cime di Lavaredo, redrawn from Mietto (1991). 5: unnamed tridactyl footprint, Monte Pelmetto, redrawn from Mietto (2000), ? Late Carnian. 6: unnamed tridactyl footprint, Ciasera Cjasavent, redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 7: unnamed tridactyl footprint, Ciol della Fratta (CFA1-3), redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 8: cf.*** **Sphingophus** ***sp., Ciol della Fratta (CFA1-3), redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 9: unnamed tridactyl footprint, Susaibes, redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 10: unnamed archosaurian trackway, Dogna, redrawn from Dalla Vecchia (1996), Carnian. 11: unnamed archosaurian trackway, Passo Giau, Carnian. 12: unnamed archosaurian trackway, Setsass, Carnian. 13: ? Prosauropod trackway, Monte Pelmetto, redrawn from Mietto (1988), ? Late Carnian. 14: unnamed quadrupedal archosaurian trackway, Ciol della Fratta, redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 15: ? Chirotheroid trackway, Susaibes, redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian. 16: unnamed trackway, Val Scandoler, redrawn from Dalla Vecchia and Mietto (1998), ? Late Carnian – Early Norian.***

include hetosaurs and or phytosaurs (cfr. *Apatopus* sp.), but also document the possible presence of dinosaurs with functionally tridactyl pes, among which, perhaps theropods and basal ornitischia; the presence of theromorph reptiles cannot be excluded (cfr. *Terapsipus* sp.) (Fig. 2).

In the Upper Tuvalian the Southern Alps were transformed into a wide carbonate tidal flat that persisted until the late Lower Jurassic (Toarcian). The stratigraphically lowest ichnosites (Dolomia Principale) like for example that of Monte Pelmetto (Mietto, 1988; 2000), could belong to the Upper Tuvalian or close to the Carnian/Norian boundary. The prints in this phase reveal the existence of an association in which true dinosaurs coexisted alongside the last basal Archosaurs (Monte Pelmetto and similar finds in Carnia and Dogna) (Dalla Vecchia, 1996; Dalla Vecchia and Mietto, 1998). Isolated tridactyl mesaxonic footprints are attributed mostly to medium to large theropod dinosaurs, whereas some bipedal tracks are probably referable to basal ornithischia and light – bodied prosauropods. The quadrupedal tracks are referable to "thecodonts" (chirotheroid tracks) and to heavy – bodied prosauropod dinosaurs (Mietto, 1988; 1991; 2000; Leonardi and Avanzini, 1994; Dalla Vecchia and Mietto, 1998). The variety, quantity and diversification reveal the persistence of emerged land that was located to the south by the Southern Alps.

The conditions of Bahamian type carbonate tidal flats, at least in part emerged, remained the same throughout the Lower Jurassic. The passage between the Triassic and the Jurassic is characterised by the disappearance of *Chirotherium* –like footprints and the massive appearance of dinosaur prints.

The Hettangian to Pliensbachian layers of the Calcari Grigi Formation preserve the richest ichnoassociation of the Southern Alps and our outcrop area could be defined as a megatracksite (Leonardi and Mietto, 2000; Avanzini, 1997; 1998; 2001; 2002b; Avanzini *et al.* 1997; 2000b; 2001c; 2001d; Mietto and Roghi, 1994; Mietto *et al.*, 2000; Avanzini and Tomasoni, 2002). Around the lower part of the Jurassic carbonate platform (Hettangian/Sinemurian), quantitative analysis, carried out on palinomorphs, showed that the generally dry conditions documented by the abundant presence of circumpollens (*Corollina* ssp.) were interrupted by a humid event, which is demonstrated by the abundant presence of typical freshwater life forms (i.e. *Porcellispora* sp.). This event has been recognised within layers corresponding to those trampled by dinosaurs (Avanzini *et al.*, 2000; Avanzini, 2002b). Other footprints are preserved in Sinemurian and Pliensbachian levels in which the presence of continental vegetables and fern pollen, document humid conditions that would have aided the formation of wide brackish ponds (Avanzini *et al.*, 2000b).

The ichnotaxa identified are *Grallator*, *Eubrontes* and *Kayentapus* related to theropod dinosaurs (Leonardi and Mietto, 2000; Mietto *et al.*, 2000, Piubelli, 2002) and *Anomoepus* belonging probably to primitive ornithopods (perhaps "fabrosaurids") (Avanzini *et al.*, 2001) (Figg. 3, 4). There are several tracks that are attributed to primitive sauropods and resemble *Parabrontopodus* Lockley, Farlow and Meyer, 1994 ichnogenus of the Jurassic of the USA and *Breviparopus* Dutuit and Ouazzou, 1980 from the Jurassic of Morocco. A new sauropod – related ichnotaxa has been recently recognised and it is at present under study (Avanzini 2003). To date they seem to be among the oldest true sauropod tracks found in the world (Dalla Vecchia, 1994, Avanzini, 2003). Some poorly preserved tracks are also attributed to prosauropods and possibly to Thyreophora (Avanzini *et al.*, 2002).

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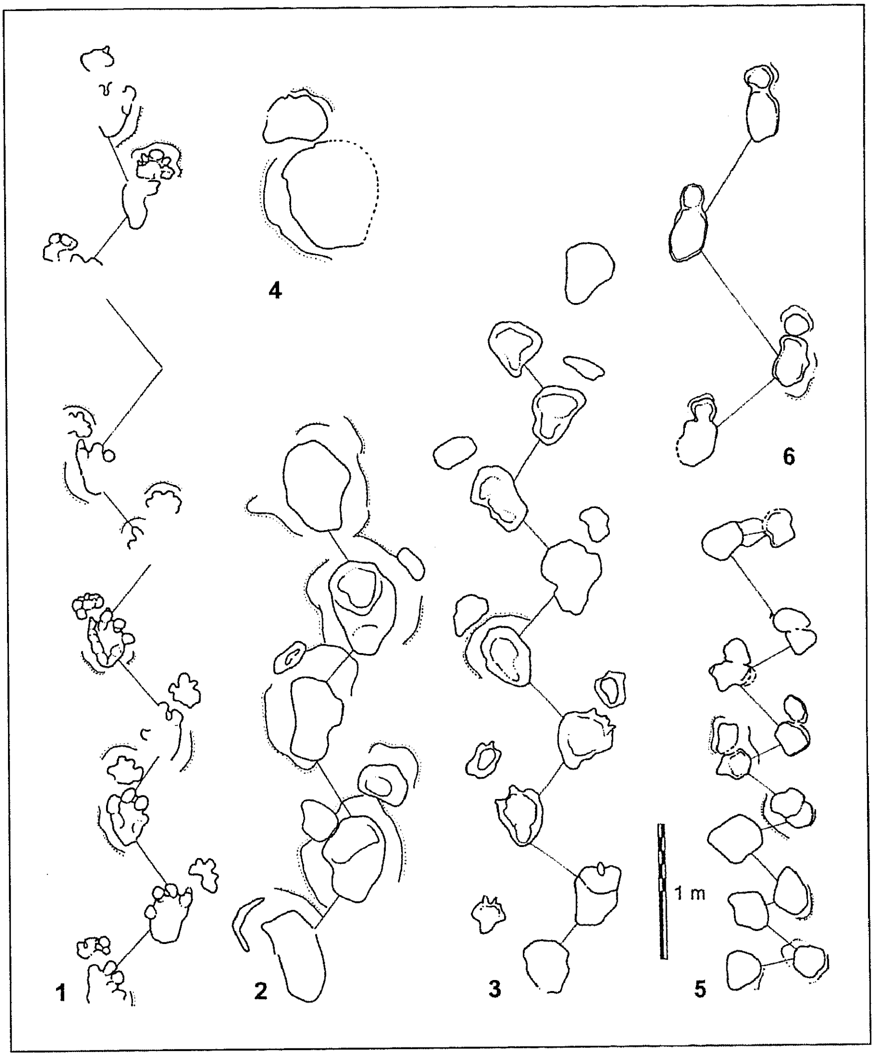

FIGURE 3. ***Early Jurassic tracks from the Southern Alps (Valle dell'Adige) (same scale: 1 m). 1: unnamed basal sauropod trackway, Lavini di Marco, Late Hettangian – Early Sinemurian. 2: unnamed sauropod trackway (ROLM28), redrawn from Leonardi and Mietto 2000, Lavini di Marco, Late Hettangian – Early Sinemurian. 3: unnamed sauropod trackway (ROLM75), redrawn from Leonardi and Mietto 2000, Lavini di Marco, Late Hettangian – Early Sinemurian. 4: unnamed sauropod manus-pes couple, redrawn from Avanzini (1997) Becco di Filadonna? Early Sinemurian? 5. Thyreophora trackway, redrawn from Avanzini et al. (2002), Valle del Sarca, Late Sinemurian – Pliensbachian. 6: unnamed quadrupedal trackway, redrawn from Avanzini et al. (2002), Valle del Sarca, Late Sinemurian – Pliensbachian.***

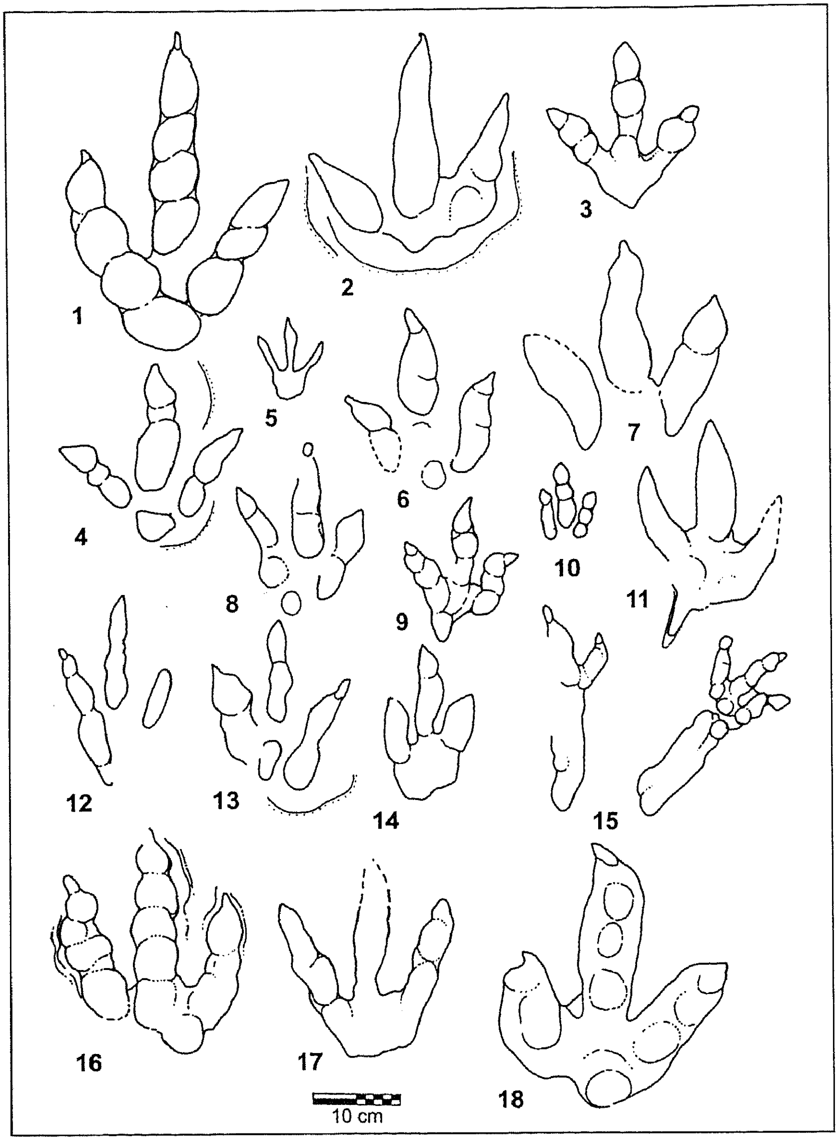

FIGURE 4. ***Early Jurassic tridactyl footprints from the Southern Alps (Valle dell'Adige) (same scale: 10 cm). 1-14: tridactyl theropod footprints, redrawn from Leonardi and Mietto (2000) and from Piubelli (2002), Lavini di Marco, Late Hettangian – Early Sinemurian. 15:*** **Anomoepus** ***sp., redrawn from Avanzini et al. 2001), Lavini di Marco, Late Hettangian – Early Sinemurian. 16: unnamed tridactyl footprint, Chizzola, Late Hettangian – Early Sinemurian. 17: unnamed tridactyl footprint, Pizzo di Levico, redrawn from Avanzini and Tomasoni (2000) Late Hettangian – Early Sinemurian. 18:*** **Kayentapus** ***sp., redrawn from Mietto et al. (2000), Bella Lasta, Sinemurian.***

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In the Toarcian/Aalenian the main part of the Southern Alps drowned and the carbonate platforms persisted only in a limited southeastern sector (the northern part of the Adriatic-Dinaric Platform) close to the Istrian peninsula. In the Southern Alps the tetrapods disappeared and the vertebrates continued our history in the tidal facies of the Cretaceous of Istrian peninsula, (Dalla Vecchia and Venturini, 1995; Dalla Vecchia, 1994b; 1996b; 1997; 1998a; 1998b; Dalla Vecchia *et al.*, 1993; 2000).

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REFERENCES

Abel, O., 1926. Der erste Fund einer Tetrapodenfährte in den unteren alpinen Trias. *Paläontologische Zeitschrift.* (7), 22-24.

Avanzini M., 1997. Impronte di sauropodi nel Giurassico inferiore del Becco di Filadonna (Piattaforma di Trento – Italia settentrionale). *Studi Trent. Sc. Nat., Acta Geol.*, 72 (1995), 193-198.

Avanzini M., 1998. Resti di vertebrati dal Giurassico inferiore della Piattaforma di Trento (Italia settentrionale). Nota preliminare. *Studi Trent. Sc. Nat. Acta Geol.*, 73 (1996), 75-80.

Avanzini M., 1999. New Anisian vertebrate tracks from the Southern Alps (Val d'Adige and Valle di Non – Italy). Riv. Mus. Civ. Sc. Nat. "E.Caffi". (20), 17-21.

Avanzini M., 2000. *Synaptichnium* tracks with skin impressions from the Anisian (Middle Triassic) of the Southern Alps (Val di Non - Italy). *Ichnos.* (7, 4), 243-251.

Avanzini M., 2002a. Dinosauromorph tracks from the middle Anisian (middle Triassic) of the Southern Alps (Valle di Non - Italy). *Bollettino della Soc. Pal Italiana.*(41,1), 37-40.

Avanzini M., 2002b. *The dinosaur site at the Lavini di Marco and the Lower Jurassic Calcari grigi Megatracksite. In*: Santantonio M. (ed.) General Field Trip Guidebook, 6th International Symposium on the Jurassic System 12 – 22 September 2002, Palermo, Italy, 279-281.

Avanzini M., 2003. *Tetrazoum cheminii* ichnogen., ichnosp. nov., a basal sauropod track from the Early Jurassic of the Italian Alps. Submitted to Ichnos.

Avanzini M., Neri C., 1998. Impronte di tetrapodi da sedimenti anisici della Valle di Non (Trentino occidentale - Italia): nota preliminare. *Annali del Museo di Storia Naturale di Ferrara.* (1), 5-19.

Avanzini M., Frisia S., Van Den Driessche K., Keppens E., 1997. Decline of dolomitization and the rise of dinosaurs. A tracksite in the Early Liassic tidal flat at the margin of the dolomites (Italy): palaeoenvironmental implications. *Palaios* (12), 538-551.

Avanzini M., Dalla Vecchia F.M., Gianolla P., Mietto P., Roghi G., 2000a. Aspetti stratigrafici relativi alla presenza di tetrapodi nelle piattaforme carbonatiche mesozoiche del Sudalpino. In: a Cherchi A., Corradini C. (eds.) *Crisi biologiche, radiazioni adattive e dinamica delle piattaforme carbonatiche: convegno di fine progetto nazionale di ricerca COFIN 97* : Modena, 13-14 giugno 15-20.

Avanzini M, Leonardi G., Mietto P., Roghi G., 2000b. Icnofaune dinosauriane nel Giurassico inferiore della Piattaforma di Trento : aspetti stratigrafici, paleoambientali e paleogeografici. *In*: Carulli G.B., Longo Salvador G. (eds.), *Riassunti delle comunicazioni orali e dei poster : 80a Riunione estiva* : Trieste, 6-8 settembre 2000, Società geologica italiana, 42-44.

Avanzini M., Ceoloni P., Conti M.A., Leonardi G., Manni R., Mariotti N., Mietto P., Nicosia U., Santi G., Spezzamonte M., 2001a. Tetrapod footprints as key elements of the Permo-Triassic continental biochronology. *Act. Int. Congr. "The Continental Permian of the Southern Alps and Sardinia (Italy). Regional repots and general Correlations"*, Pavia. *Ann. Mus. Civ. Sc. Nat. Brescia. Monografia* (25), 89-107.

Avanzini M, Ferretti P., Seppi R,. Tomasoni R., 2001b. Un grande esemplare di orma "dinosauroide" *Parachirotherium* sp. Kuhn 1958 dall'Anisico superiore (Illirico) del Sudalpino. *Studi Trent. Sc. Nat. Acta Geol*, (76–1999), 201-204.

Avanzini M., Gierlinski G., Leonardi G. 2001c. First report of sitting *Anomoepus* tracks in european Lower Jurassic (Lavini di Marco site - northern Italy). *Riv. Ital. Pal e Strat. Milano*, (107, 1),131-136.

Avanzini M, Leonardi G., Tomasoni R., 2001d. Enigmatic dinosaur trackways from the Lower Jurassic (Pliensbachian) of the Sarca Valley, Northeast Italy. *Ichnos*: 8: 235-242.

Avanzini M., Leonardi G., 2002. *Isochirotherium inferni* ichnosp. n. in the Upper Anisian (Illirian) of Adige Valley (Bozen – Italy). *Bollettino della Soc. Pal Italiana*, (41,1), 41-50.

Avanzini M., Lockley M., 2002. Middle Triassic archosaur ontogeny and population structure: interpretation based on *Isochirotherium delicatum* fossil footprints (Southern Alps – Italy). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 185 (3-4)391-402.

Avanzini M., Renesto S., 2002. A review of *Rhynchosauroides tyrolicus* Abel, 1926 ichnospecies and some inferences on middle Triassic (Anisian-Ladininian) *Rhynchosauroides* ichnogenus trackmaker. *Riv. Ital. Pal e Strat.* (108,1), 51-66.

Avanzini M., Tomasoni R., 2002. I Calcari Grigi di Cima Vezzena – Pizzo di Levico. *Studi Trent. Sc. Nat. Acta Geol*, (77-2000), 245-267.

Brandner, R., 1973. Tetrapodenfährten aus der unteren Mitteltrias der Südalpen. *Festschrift Heissel Veröffentlichungen der Universität Innsbruck.* (86), 57-71.

Bizzarini F., Rottonara E.,1997. La tanatocenosi a vertebrati delle Heiligekreuzschichten in alta Val Badia – Dolomiti. *Boll. Mus. St. Nat. Venezia.* (47), 307-316.

Conti M.A., Leonardi G., Mietto P., Nicosia U., 2000. Orme di tetrapodi non dinosauriani del Paleozoico e Mesozoico in Italia. In: Leonardi G. and Mietto P. (eds*.), Le orme giurassiche dei Lavini di Marco (Trentino) e gli altri resti fossili italiani.* Accademia Editoriale, Pisa/Roma, 297-320.

Dalla Vecchia F.M., 1994a. Jurassic and Cretaceous sauropod evidence in the Mesozoic carbonate platforms of the Southern Alps and Dinarids. *Gaia* (10), 65-73.

Dalla Vecchia F.M., 1994b. I dinosauri dell'Istria. *In*: Ligabue G. (ed.): Il tempo dei Dinosauri. *Quaderni de Le Scienze.* (76), 63-68.

Dalla Vecchia F.M.,1996a. Archosaurian trackways in the Upper Carnian of Dogna Valley (Udine, Friuli, NE Italy). *Natura Nascosta.* (12), 5-17.

Dalla Vecchia F.M.,1996b. Dinosaur track sites in the Cretaceous of Istria (Croatia), *56 Annual Meeting Society of Vertebrate Palaeontology* Abstract of papers, *Journ. Vert. Pal.* (16) 30A.

Dalla Vecchia F.M.,1997. Terrestrial tetrapod evidence of the Norian (late Triassic) and Cretaceous carbonate platforms of the Northern Adriatic region (Italy, Slovenia and Croatia). *Sargetia, ser. Sci. Nat.* (17), 177-201.

Dalla Vecchia F.M., 1998a. Remains of Sauropoda (Reptilia, Saurischia) in the Lower Cretaceous (Upper Hauterivian/Lower Barremian) limestones of SW Istria (Croatia). *Geol. Croat.* (51), 105-134.

Dalla Vecchia F.M., 1998b. Theropod footprints in the Cretaceous Adriatic-Dinaric carbonate Platform (Italy and Croatia). *Gaia* (15), 355-367.

Dalla Vecchia F.M., 1999. A sauropod footprint in a limestone block from the Lower Cretaceous of northeastern Italy. *Ichnos* (6), 269-275.

Dalla Vecchia F.M., 2000. I reperti ossei dei tetrapodi continentali paleozoici e mesozoici in Italia. In: Leonardi P. and Mietto P. (eds): *Le orme giurassiche dei Lavini di Marco (Trentino) e gli altri resti fossili italiani.* Accademia Editoriale, Pisa/Roma, 321-335.

Dalla Vecchia F.M., Mietto P., 1998. Impronte di rettili terrestri nella Dolomia Principale (Triassico superiore) delle Prealpi carniche (Pordenone, Friuli). *Atti Tic. Sc. Terra,* s. spec. (7-1997), 87-107.

Dalla Vecchia F.M., Tarlao A., Tunis G., 1993. Theropod (Reptilia/Dinosauria) footprints in the Albian (Lower Cretaceous) of the Quieto/Mirna river mouth (NW Istria, Croatia) and dinosaur population of the Istrian region during the Cretaceous. *Mem. Sc. Geol.* (45), 139-148.

Dalla Vecchia F.M., Tarlao A., Tunis G., Venturini S., 2000. New dinosaur track sites in the Albian (Early Cretaceous) of the Istrian Peninsula (Croatia). *Mem. Sc. Geol.* (52), 193-292.

Dalla Vecchia F.M., Venturini S., 1995. A theropod (Reptilia, Dinosauria) footprint on a block of Cretaceous limestone at the pier of Porto Corsini (Ravenna, Italy). *Riv. Ital. Paleont. Strat.*, (101), 93-98.

Dalla Vecchia F., Avanzini M., 2002. New remains of Triassic reptiles from north-eastern Italy. *Bollettino Soc. Pal. Italiana,* 41 (2-3).

Gianolla P., De Zanche V., Mietto P., 1998a. Triassic sequence stratigraphy in the Southern Alps (Northern Italy). *Definition of sequences and basin evolution.* SEPM Spec. Publ. (60), 723-751.

Gianolla P., Ragazzi E., Roghi G., 1998b. Upper Triassic amber from the Dolomites (Norther Italy). A palaeoclimatic indicator? *Riv. It. Pal. Strat.* (104, 3), 381-390.

Leonardi G., Avanzini M., 1994. Dinosauri in Italia. In: *Il tempo dei dinosauri* Ligabue G. (ed.),. *Le Scienze.* (76), 69-81.

Leonardi G., Mietto P. (eds), 2000. *Dinosauri in Italia: Le orme giurassiche dei Lavini di Marco (Trentino) e gli altri resti fossili italiani.* Accademia Editoriale, Pisa/Roma, 490 pp.

Mietto P., 1986. Orme di tetrapodi nella Formazione di Werfen del Recoarese. *Riv. It. Paleont. Strat.* (92,3), 321-326.

Mietto, P., 1987. *Parasynaptichnium gracilis* nov. ichnogen., nov. isp.. (Reptilia: Archosauria Pseudosuchia) nell'Anisico inferiore di Recoaro (Prealpi vicentine - Italia). *Mem. Sc. Geol.* (39), 37-47.

Mietto P., 1988. Piste di dinosauri nella Dolomia Principale (Triassico superiore) del Monte Pelmetto (Cadore). Mem. Soc. Geol. It., 30 (1985), 307-310.

Mietto P., 1991. Impronte di dinosauri nel triassico superiore delle Dolomiti. In: AA.VV. (eds.): Dinosaurs, Manfrini, 83-87.

Mietto P., 2000. La sezione geologica del Museo della Val Fiorentina. In *Storia, Archeologia e Geologia della Val Fiorentina.* : Associazione Cilturale "Amici del Museo" di Selva di Cadore (eds.). Museo di Selva di Cadore, 7-29.

Mietto P., Roghi G., 1994. Nuova segnalazione di impronte di dinosauri nel Giurassico inferiore del Sudalpino: le piste della Valle di Revolto (Alti Lessini Veronesi). *Paleocronache,* 1993, 39-43.

Mietto P., Roghi G., Zorzin R., 2000. Le impronte di dinosauri liassici dei Monti Lessini veronesi. *Boll. Mus. Civ. St. Nat. Verona.* (24), 55-72.

Piubelli D., 2002. Nuove indagini icnologiche sul sito Giurassico dei Lavini di Marco (Rovereto – Trento). Unpublished MS Thesis, Università di Padova, Department of Geological Science, A.A.2001-2002, 113p.

Sirna, G., Dalla Vecchia, F.M., Muscio, G., Piccoli, G., 1994. Catalogue of Paleozoic and Mesozoic Vertebrates and vertebrate localities of Tre Venezie area (North Eastern Italy). *Mem. Sc. Geol.* (46), 255-281.

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CDU 582.28 (460.21)
AGUSTÍN CABALLERO MORENO
JESÚS PALACIOS REMONDO
Aportación al catálogo micológico de La Rioja (España): el género *peziza* linneo ex amans
Contribution to the micological catalogue from La Rioja (Spain): the genera Peziza *Linneo ex Amans*
ZUBÍA, 2003, 21, pp. 9-27
They are collected 23 taxa of the genera Peziza *as amplification of the fungi catalogue from La Rioja (Spain). The appointments and data on their distribution, ecology, fruiting season and commentaries on taxonomy are added. Microscope drawings of the spores of the species treated and photographies about some taxa are included.*
Key words: Peziza, Ascomycetes, catalogue, ecology, chorology, La Rioja, Spain.
Palabras clave: Peziza, Ascomycetes, catálogo, ecología, corología, La Rioja, España.

CDU 582.32 (460.21)
J. MARTÍNEZ ABAIGAR
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Daños macroscópicos y microscópicos causados por un aumento de la radiación ultravioleta-B en dos briófitos acuáticos del parque natural de Sierra Cebollera (La Rioja, norte de España)
Macroscopic and microscopic damage cased by enhanced ultraviolet-B radiation on two aquatic bryophytes from the natural park of Sierra Cebollera (La Rioja, nortern Spain)
ZUBÍA, 2003, 21, pp. 29-49
The depletion of the stratospheric ozone layer as a result of anthropogenic emissions of halogenated carbon compounds may cause an increase in the ultraviolet-B radiation (UV-B: 280-315 nm) at ground level. In order to assess the effects of enhanced UV-B radiation on aquatic bryophytes and their possible use as bioindicators, two species were cultured in the laboratory for 82 days with a supplement of UV-B radiation and their macro- and microscopic responses were observed. Also, the effect of temperature (2 °C and 10 °C) on the development of damage was tested. The moss Fontinalis antipyretica *and the leafy liverwort* Jungermannia exsertifolia *subsp.* cordifolia, *coming from the Natural Park of Sierra Cebollera (La Rioja, northern Spain), were used.*

The moss was sensitive to both cold and enhanced UV-B radiation, and the damage caused by both factors were quite similar: brown colour, depressed growth, development of the central fibrilar body, chloroplast disappearance and presence of protoplasts progressively vesiculose, vacuolized and finally hyaline ("empty cells"). These symptoms are little specific and have been described in several pleurocarpous mosses as a response to diverse processes of senescence and stress (both natural and anthropogenic). The unique specific response to the enhanced UV-B radiation was a colour change in the cell walls, from yellow to orange-brown. This could be due to either an enhanced synthesis of UV-absorbing compounds or to a degradation of the cell walls.
The liverwort was sensitive to enhanced UV-B radiation only when this stress was applied simultaneously with cold stress, showing then greyish-brown leaves and depressed growth, although cellular damage was low. The remaining samples looked healthy and their macro- and microscopic appearances were quite similar.
The higher UV-B tolerance shown by Jungermannia exsertifolia *subsp.* cordifolia *as compared with that of F.* antipyretica *could be due to the presence of UV-absorbing compounds in the protoplasts of the former species. This tolerance may justify the contrasted ecological and chorological ranges of both species, since the more montane character typical of the liverwort could be related to a specific resistance to cold and UV-B radiation, which are common stresses in the environments in which it dominates.*
Our results suggest that the sensitivity of aquatic bryophytes to enhanced UV-B radiation is species-specific, and thus their use as bioindicators should be based on a meticulous selection of both the species and the variables employed. The colour change of the cell walls of F. antipyretica *seems to be the most specific and adequate symptom to achieve this particular objective.*
Key words: Aquatic bryophytes, *Fontinalis antipyretica, Jungermannia exsertifolia* subsp. *cordifolia,* ultraviolet-B (UV-B) radiation, morphology, streams, bioindicators, La Rioja, Spain.
Palabras clave: Briófitos acuáticos, *Fontinalis antipyretica, Jungermannia exsertifolia* subsp. *cordifolia,* radiación ultravioleta-B (UV-B), morfología, arroyos, bioindicadores, La Rioja, España.

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CDU 599 (460.21)
ÁLVARO CAMIÑA CARDENAL
Preferencias de hábitat en una comunidad de grandes mamíferos en La Rioja durante el otoño e invierno
Habitat preferences in a big mammal's community during autumn and winter in La Rioja (northern Spain)
ZUBÍA, 2003, 21, pp. 51-62
*We analyse the habitat preferences of the wild boar, red and roe deers and the fox inhabiting the mountains of Sistema Iberico Septentrional (Northern Spain). Using factor analysis we reduced seven variables to three major habitat components that explained 79.62 % of the variance. Relationships between abundance of these species and factor components were analysed by means of correlation and stepwise multiple regression. Wild boar density showed positive correlation with both the cobertures of pyreneean (*Quercus pyrenaica*) and deciduous lusitanian oaks (*Q. faginea*) (FSII) and slope of hills (FSIII). The stepwise multiple regression model selected the same factor scores (the model explained a 34.20 % of the variance). For the rest of species only roe deer density showed significant correlation with the northern type woods. The regression model had a much weaker predictive power (8.27 %), only FSII was selected. Red deer density and fox abundance showed no correlation with any of the habitat gradients. Moreover, the relationships between these species and roe deer were also non-significant. Floristic composition seemed not to be a good predictor of animal abundance. Only the wild boar showed a clear preference for oak forests due to the fact that is in such type of forests that it finds its main food source (acorns) during autumn and winter seasons.*
Key words: fox, game, management, red deer, roe deer, wild boar.
Palabras clave: caza, ciervo, corzo, jabalí, manejo, zorro.

CDU 599.4 (460.21)
PABLO T. AGIRRE-MENDI
Protección de Refugios de Quirópteros (Mammalia: Chiroptera) en la Comunidad Autónoma de La Rioja: resultados de las campañas de 1998, 1999, 2000 y 2001
Protection of Bat (Mammalia: Chiroptera) Roosts in the Autonomous Territory of La Rioja (Spain): results of the years 1998, 1999, 2000 y 2001
ZUBÍA, 2003, 21, pp. 63-70
In the year 1998 the Government of the Autonomous Territory of La Rioja (N-Spain) promulgated the 56th Decree of 23 of June for the regulation of the subsidies for the protection of some bat species colonies located in private buildings. This study analyses the results of the firs four years of work of this law. The total quantity of different colonies subsidied is 14. The quantity of requests, colonies subsidied and the total amount of the helps have been increased year after year. The most of the subsidied colonies are reproduction groups (97,14 %) and they are located in the Northern Iberian system and their contact area within the Ebro valley (78,57 %). Colonies are species specific with a clear dominance of R. hipposideros (92,86 %) on M. emarginatus (7,14 %) and the subsidies include some the most important colonies of the region. Finally, the development of these regulations is considered very positively in relation to the conservation of these cited species and possible lines of future actuation are suggested.
Key words: bats, roost, La Rioja, Spain, subsidies.
Palabras clave: quirópteros, refugios, La Rioja, subvenciones.

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CDU 631.459 (460:282) EBRO
TEODORO LASANTA MARTÍNEZ
Gestión agrícola y erosión del suelo en la cuenca del Ebro: el estado de la cuestión
Agricultural management and soil erosion at the Ebro Bassin: Current situation of the theme
ZUBÍA, 2003, 21, pp. 71-96

The aim of this article is to review the studies about soil erosion of the Ebro Bassin. Metodology features, the most important soil erosion processes and its main hidrological consequences are higlighted. The results point out that the greates losses of soil are registered during the phase of cultivation and not with the abandonment. It is also noted that labour systems influence the run off and the erosion taxes.

Key words: Soil erosion, agricultural land, abandoned fields, erosion processes, Ebro Bassin (Spain).
Palabras clave: Erosión del suelo, tierras agrícolas, campos abandonados, procesos de erosión, Cuenca del Ebro (España).

CDU 631.8 929 Moreno, Francisco
JOSÉ MARÍA DE JAIME LORÉN
JOSÉ DE JAIME GÓMEZ
Francisco Moreno: colmenero de Autol (La Rioja) que con Diego de Torres y Villarroel compuso el primer libro sobre esta disciplina de la ilustración española
ZUBÍA, 2003, 21, pp. 97-117

CDU 519.21
JOSÉ JAVIER ESCRIBANO BENITO
Sixto Cámara y los fundamentos del cálculo de probabilidades
Sixto Cámara and the Foundations of Probability Calculus
ZUBÍA, 2003, 21, pp. 119-128

The Spanish Mathematician Sixto Cámara was one of the first at introducing the Mathematical Statistics teaching in the Spanish University. In this article it is made a historic study of the speech "Chance and Foundations of Probability Calculus" which was mentioned by Cámara during the opening of the 1933/1934 academic course. In his speech, Cámara analyses the historic evolution of the mathematics and philosophic foundations in probability calculus. In fact, it is a well-documented exposition with numerous bibliographic references and an approach which, excluding some subjective nuances, emphasizes the aspects considered more important these days.

Key words: Sixto Cámara, probability calculus, mathematics, philosphic, Spain, XX century.
Palabras claves: Sixto Cámara, cálculo de probabilidades, matemáticas, filosofía, España, siglo XX.

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PETER M. GALTON
JAMES O. FARLOW
Dinosaur state park, Connecticut, USA: history, footprints, trackways, exhibits
ZUBÍA, 2003, 21, pp. 129-173

Dinosaur trackways in the East Berlin Formation (Lower Jurassic, Hettangian, ~205 mya) at Dinosaur State Park, Rocky Hill, Connecticut mostly occur on the main surface and as corresponding under tracks. The prints belong to the ichnogenera Eubrontes *and/or large* Anchisauropus, *and were probably made by theropod dinosaurs. There is no obvious preferred orientation of trackways, which may have been made by animals, either alone or in small groups, over a month or more. This time would be needed for the lake level to go down by about 2 m, the depth indicated by short sequences of prints interpreted as "swimmer" tracks. In these footprints, only the claws imprint to form three narrow sub-parallel grooves with mud pushed up at the posterior ends. However, these strange characteristics could have resulted from foot-substrate interactions during the three phases of contact on an emergent firm substrate. Thus, all the trackways may actually have been made over a day or so at the most. The associated exhibits at the Park, which include fossil plants, fish and other foot prints plus life size dioramas, explain the geology, history and paleontology of the Connecticut Valley and of the Park.*

Key words: Dinosauria, Theropoda, *Eubrontes*, Lower Jurassic, Footprints, Connecticut USA.
Palabras clave: Dinosauria, Theropoda, *Eubrontes*, Jurásico inferior, huellas, Connecticut USA.

CDU 568.19
MARCO AVANZINI
Tetrapod footprints from the Mesozoic carbonate platforms of the italian Alps
ZUBÍA, 2003, 21, pp. 175-186

In the Italian Alps, the presence of tetrapods is documented from the Late Carboniferous to the Cretaceous with an interruption in correspondence with the Late Jurassic (Dogger-Malm). The traces of vertebrate are well represented in the sediments of the middle Triassic in which large chirotheriid archosaurs and smaller lepidosauromorpha tracks are documented. Among these ichnoassociations there are some specimens with functionally tridactyl dinosauromorph pes. In the Carnian the ichnofauna shows a diversified biomass, probably of gondwanic affinity. In this assemblage some specimens can be probably attributed to primitive dinosaurs with functionally tridactyl feet as well as possible quadruped or semi-biped prosauropods. In the Late Carnian the prints reveal the existence of an association in which true dinosaurs coexisted alongside the last basal Archosaurs. Isolated tridactyl footprints are attributed mostly to medium to large theropod dinosaurs, whereas some bipedal tracks are probably referable to basal ornithischia and light – bodied prosauropods. The passage between the Triassic and the Jurassic is characterised by the disappearance of Chirotherium -like footprints and the massive appearance of dinosaur footprints.

Key words: Archosaur footprints, dinosaur footprints, Triassic, Jurassic, Northern Italy.
Palabras clave: Pisadas de arcosaurios, Pisadas de dinosaurios, Triásico, Jurásico. Norte de Italia.