

Earliest records of theropod and mammal-like tetrapod footprints in the Upper Triassic of Sichuan Basin, China

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Abstract *Eubrontes*- and *Grallator*-sized theropod footprints are known from two localities in the Upper Triassic Xujiache Formation of the Sichuan Basin, southwest China. The larger footprints include a partial trackway with two successive pes imprints that were named as *Pengxianpus cifengensis*. Compared with robust *Eubrontes*, they have slender digits, less well-defined pad impressions and display a wider digit divarication similar to the theropod ichnotaxon *Kayentapus* from the Late Triassic-Early Jurassic. Presently, a synonymy of the latter cannot be proved conclusively and the ichnotaxon is retained here. For both footprints, some small areas preserve skin texture with polygonal scales, the clearest preservation is in a small area on the metatarsal-phalangeal pad IV of the second imprint. The smaller theropod footprints are also part of an incomplete trackway. They show a wide digit divarication similar to *Kayentapus* and *Pengxianpus* but they are here tentatively referred to theropod footprints indet. A peculiarity on the surface with *Pengxianpus* is the presence of small pes or manus imprints that can be assigned to mammal-like tetrapods somewhat similar to those known from Triassic-Jurassic strata of North America and southern Africa. This is the first report of mammal-like footprints in the Triassic of southeastern Asia.

Key words Sichuan Basin, China; Late Triassic; Xujiache Formation; theropod tracks; mammal-like tracks

1 Introduction

Tridactyl theropod tracks from the Late Triassic are known from assemblages in North America (Weems, 1987; Lockley and Hunt, 1995; Olsen et al., 1998; Gaston et al., 2003; Lucas et al., 2006, 2010), South America (Marsicano and Barredo, 2004; Melchor and De

Valais, 2006; De Valais and Melchor, 2008); Greenland (Jenkins et al., 1994), North Africa (Lagnaoui et al., 2012), southern Africa (Ellenberger, 1970, 1972; Olsen and Galton, 1984), Europe (Gierliński and Ahlberg, 1994; Haubold and Klein, 2000, 2002; Gand et al., 2005; Niedźwiedzki, 2011) and Australia (Thulborn, 1998). Most of them can be assigned to an ichnotaxonomic grouping referred to as *Grallator-Anchisauripus-Eubrontes* plexus (Olsen, 1980; Milner et al., 2009) or to *Kayentapus* (Welles, 1971; Weems, 1992; Piubelli et al., 2005; Lockley et al., 2011). The former grouping comprises tridactyl pes imprints of principally similar grallatorid shape but different sizes, where *Grallator* is the smallest (≤ 15 cm length), *Anchisauripus* is of medium size (15-25 cm length) and *Eubrontes* is the largest (>25 cm length). *Kayentapus* was first described from the Lower Jurassic of Arizona by Welles (1971) being a large footprint of *Eubrontes*-size, however, it is distinct from the latter by the more slender digits that show a relatively wide divarication. It was identified later also in the Late Triassic (Weems, 1987, 1992; Niedźwiedzki, 2011). In some areas lacking vertebrate fossils, these track records greatly contributed to the reconstruction of the dinosaur fauna. Thus far no dinosaur skeletons are known from the Late Triassic of China, and the footprints are the only evidence of their existence in this region at that time.

The coal measures of the Late Triassic Xujiahe Formation of the Sichuan Basin is a famous, coal-bearing, terrestrial facies that has yielded abundant plant and invertebrate fossils. Subsequently, dinosaur tracks were also discovered. In July 1981, the villagers from Panlongqiao Village were splitting stone and accidentally discovered two huge footprints representing part of a trackway that was described and named as *Pengxianpus cifengensis* by Yang and Yang (1987). At present *Pengxianpus cifengensis* from the Xujiahe Formation is the only endemic theropod ichnospecies from the Chinese Triassic (Lockley et al., 2013). In 1989, geologists from Chengdu University of Technology (CDUT) discovered a series of dinosaur tracks that occurred on the surface of a quartz sandstone layer at Qingyi locality of Tianquan County, Ya'an City, and collected them. Thus far no documentation was published. In 2005 Wang et al. discovered two dinosaur footprints on a gray thin-layered siltite, 50 meters lower than the fossil site where CDUT specimens were collected. However, the description of Wang et al. lacks detailed documentation and discussion. Therefore a more thorough account is given here. Wang et al. (2005) also reported a small theropod track from the Xujiahe Formation, again without any detailed description. These records represent the stratigraphically oldest theropod tracks from China. Non-dinosaurian footprints were observed by Lockley and Matsukawa (2009) on the slab with *Pengxianpus*. These are interpreted as mammal-like reptile tracks, and appear to be the first discovery of synapsid footprints in the Triassic of China. They are also described herein.

2 Material and methods

The material comes from two localities in Sichuan Province (Fig. 1): 1) Panlong (also

Panlongqiao) locality in Panlongqiao Village, Cifeng Town, Pengzhou City; 2) The Qingyi tracksite is located on the right bank of Qingyi River, 2 km away from the downtown of Tianquan County, Ya'an City. All footprints described here are preserved as convex hyporeliefs.

At the Panlongqiao locality, two natural casts comprising one step and at Qingyi locality, two imprints also comprising a single step were documented. All footprints were mapped. Outline-drawings were made on transparency film and digitalized with a vector-based drawing software based on examination of the original slabs as well as photographs. The photographs were taken under natural light conditions, the measurements correspond with the standard methods proposed by Leonardi (1987) and Haubold (1971).

Institutional abbreviations CFPC. Chongqing Museum of Natural History, Chongqing, China; TQ. Tianquan County, Sichuan, China; CDUT. The Museum of Chengdu University of Technology, Chengdu, Sichuan, China; CU. University of Colorado Dinosaur Tracks Museum, Denver, Colorado, USA.

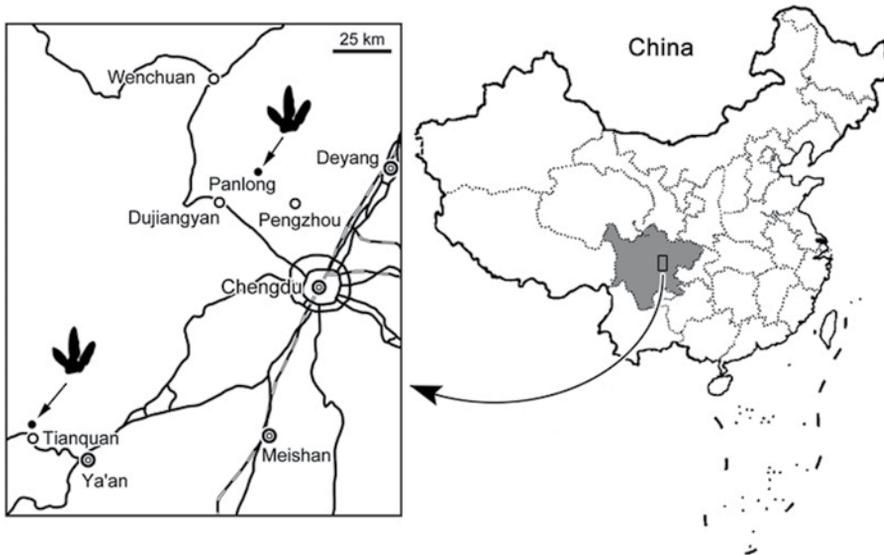


Fig. 1 Geographic position of study area with footprint localities in Sichuan Province, southwestern China

3 Geological setting

Triassic deposits are relatively scarce in the Sichuan Basin, and Triassic outcrops in the western part of the basin mainly belong to the Late Triassic (Rhaetian) Xujiahe Formation (Peng et al., 2005; Qiao et al., 2012). The Xujiahe Formation mainly consists of thick sandstone beds, mudstones, and interlayered coal seams, which form rhythmite sequences of different thicknesses, from a few hundred meters to three thousand meters, being often rich in plant and bivalve fossils (Gu and Liu, 1997).

The Panlongqiao tracksite is situated in the 3rd member of the Xujiache Formation. The lithology of this member is dominated by dark gray, black gray mudstone and siltstone, mixed with small quantities of quartz and sandstone debris that contains coal (Yang and Yang, 1987). The tracks come from the argillaceous sandstone layer in the coal measure strata. The sedimentary environment is characteristic of an estuarine facies (Yang and Yang, 1987).

The Qingyi tracksite also belongs to the 3rd member of the Xujiache Formation (Wang et al., 2005). The footprints come from a gray thin siltstone, showing ripple marks that are nearly symmetrical.

According to Wang et al. (2005) the sediments were deposited on a lakeshore shoal of a delta plain. However, compared with other members, the 3rd member of the Xujiache Formation is relatively thin, and the lithology differs significantly (see Wang et al., 2010: fig. 5.10). As the schematic illustration shows (Fig. 2) these authors selected the stratigraphic columns of Well Guangan 102 (Xu et al., 2010) for their lithological descriptions.

4 Tetrapod footprints

4.1 Panlongqiao tracksite

Ichnogenus Pengxianpus Yang & Yang, 1987

Pengxianpus cifengensis Yang & Yang, 1987 (monotypic)

Emended diagnosis Large (>25 cm length), tridactyl, mesaxonic pes imprints of a biped showing a wide digit divarication angle II-IV (up to 69°). Digits of long and slender shape with rounded pads, digit III the longest, followed by II and IV. Small, but pronounced circular metatarsal-phalangeal pad on digit IV.

Material CFPC1, CFPC2, two successive pes imprints of a trackway; CU 176.3, plaster cast of CFPC1 in the CU (Figs. 3–5).

Locality and horizon Near Panlongqiao Village, Cifeng Town, Pengzhou City, Sichuan, China (Fig. 1). The 3rd Member of the Xujiache Formation, Late Triassic (Fig. 2).

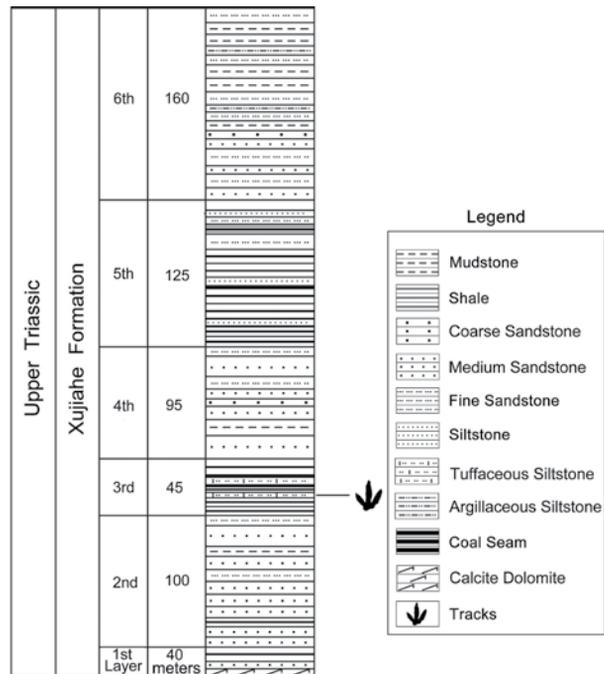


Fig. 2 Triassic stratigraphy of the Xujiache Formation in Sichuan Basin after Xu et al., 2010 with position of the track-bearing layer



Fig. 3 *Pengxianpus cifengensis*, holotype CFPC1 and CFPC2 on mudcracked surface, partial trackway with two successive pes imprints

A. photograph; B. sketch. Notice different preservation of imprints; arrows indicate footprints of mammal-like tetrapods

separated by a sharp notch along the lateral outline. Track CFPC2 is poorly preserved. It shows broad digit impressions, but the exact proportions remain obscure due to extramorphological overprinting: one digit (II) apparently left two overlapping impressions, one being very shallow; the duplication may record slippage or sliding by the track maker.

Skin impressions For both footprints, some small areas preserve skin impressions (Fig. 5). The clearest preservation is in a small area on the metatarsal-phalangeal pad IV of CFPC1. This area of polygonal scale impressions is about 32 mm long and 28 mm wide, and preserved as convex hyporeliefs. About 70 small scale impressions were observed (size <1 cm; Kim et al., 2010). Each scale typically measures from about 2.3–2.5 mm in diameter, with the largest diameter ~3.4 mm, and the smallest approximately 1 mm. The shape of impressions is variable, sub-regular to irregular, pentagonal and hexagonal. Scale impressions are mound-like, and appear more like individual tubercles than imbricated scales. A pattern of parallel

Description Partial trackway with two successive pes imprints are preserved. Their position indicates a narrow pattern with moderate pace length and orientation along digit III axis appears parallel (not rotated) relative to trackway orientation. CFPC1 is better preserved and provides the measurements in Table 1, as well as the basis for the following description. The length/width ratio of CFPC1 is 1.2. It is mesaxonic and nearly symmetrical along the digit III axis. Digit III is the longest, and digit IV is slightly shorter than digit II (Table 1). The general-shapes of digit traces are long and slender with tapering distal ends indicating the presence of claws. Pad traces are partially visible; however, their exact number remains uncertain. The possible phalangeal pad formula is ?2, 3, ?3, corresponding to digits II, III and IV. Rounded metatarsal-phalangeal pad traces are impressed proximal to the digit traces, with that of digit IV being most distinct and

Table 1 Measurements of theropod tracks from Panlongqiao and Qingyi tracksites (cm)

Number	R/L	ML	MW	LD II	LD III	LD IV	II-III	III-IV	II-IV	PL	L/W
CFPC1	R	25.8	21.8	14.4	18.9	12.1	30°	35°	65°	93	1.2
CFPC2 [#]	L	23.5	19.8	>10	16.1	16.3	22°	47°	69°	—	1.2
TQ.1	R	11.0	11.1	4.4	7.0	5.8	41°	46°	87°	33.2	1.0
TQ.2	L	10.5	10.9	5.1	7.0	4.2	57°	47°	104°	—	1.0

Abbreviations: R/L. right/left; ML. maximum length; MW. maximum width, dinosaur tracks measured as distance between the tips of digits II and IV; LD II-IV. length of digit II-IV; II-III, III-IV, II-IV. angle between digits II and III, III and IV, and II and IV respectively; PL. pace length; L/W. maximum length/maximum width.

[#] Because of the deformation, the data of CFPC2 are only for reference.

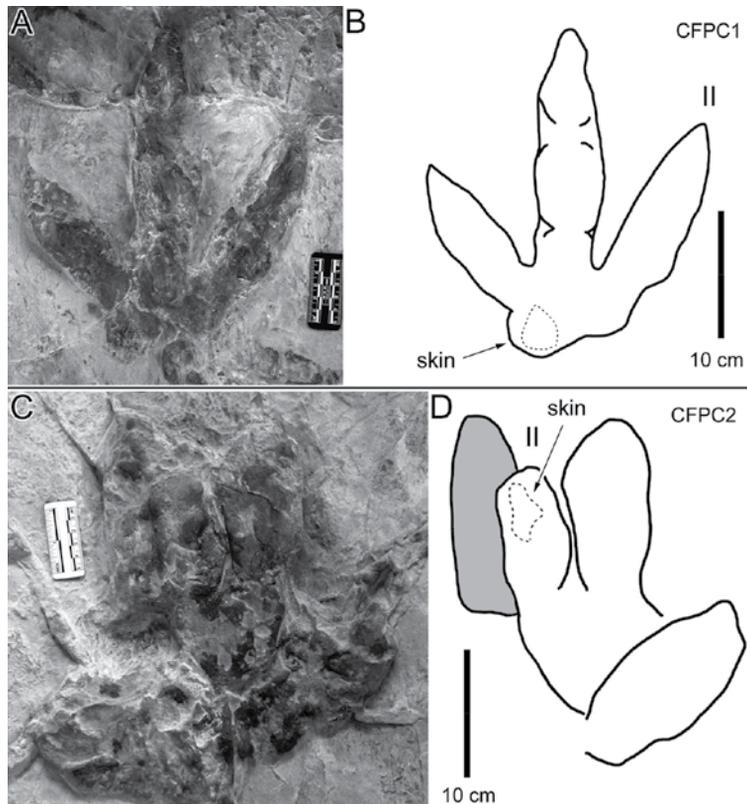


Fig. 4 Close-up view with photographs and sketches of *Pengxianpus cifengensis*, holotype A–B. CFPC1; C–D. CFPC2

rows can be observed and, as shown in Fig. 5, as many as thirteen distinct and indistinct rows can be identified. In general these skin impressions are similar to other theropod track skin traces, such as those reported from Late Triassic *Grallator* from Greenland (Gatesy, 2001), Late Cretaceous theropod (probably tyrannosaurids) skin impressions from Mongolia (Currie et al., 2003) and Middle Jurassic theropod track skin impressions from Xinjiang, China (Li

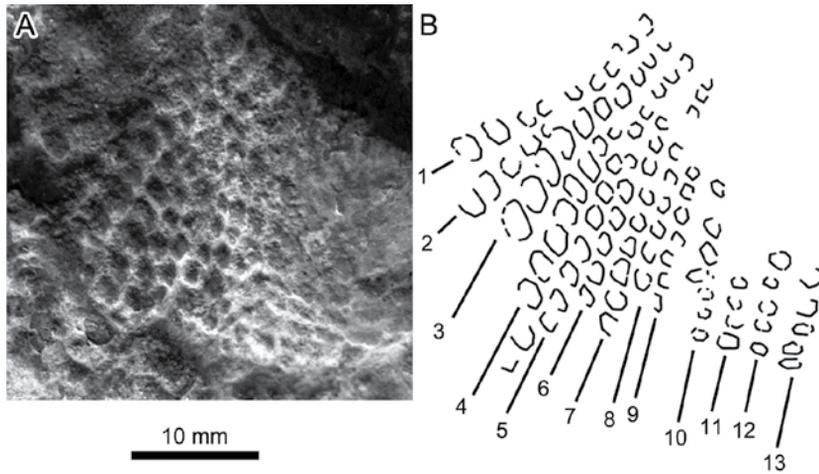


Fig. 5 Detail of CFPC1 with polygonal skin impressions in metatarsal-phalangeal pad of digit IV
A. photograph; B. sketch showing up to a dozen regular rows of polygons

Zhongdang personal observation).

Discussion Yang and Yang (1987) described and named the footprints from Panlongqiao Village as *Pengxianpus cifengensis*. However, these authors did not provide sufficient support for its diagnosis, only listing features such as (a) tetradactyl and digitigrade footprints of a biped with cartridge-shaped digits showing moderate length and width, (b) digit I separated from digit II, (c) divarication angle between digit I and digit III = 95° , (d) claws with obtuse tip on digits II-IV, (e) digits II and III subequal in length, IV shorter, (f) trackway narrow lacking a manus and tail trace, and (g) interdigital angles I-II = 70° , II-III = 30° , III-IV = 49° , I-IV = 135° (Yang and Yang, 1987). Of these ostensible criteria, (a), (b) and (c) are not valid because *Pengxianpus* unequivocally lacks digit I; (d), (e) and (f) are also present in many other theropod footprints and therefore are not diagnostic; (g) indicate a wide divarication.

Yang and Yang (1987) attributed *Pengxianpus cifengensis* to prosauropod trackmakers. They considered them to be tetradactyl and interpreted the elongate sedimentary structure at the posteromedial end as a hallux impression. Lockley et al. (2013) examined this specimen in the Chongqing Museum of Natural History, re-evaluating the footprints to be tridactyl and not tetradactyl. Lockley and Matsukawa (2009) noticed a similarity with the ichnogenus *Atreipus*. The latter was first described by Olsen and Baird (1986) from Late Triassic deposits of the Newark Supergroup based on the trackways of a quadruped, and ornithischians (Olsen and Baird, 1986) as well as dinosauromorphs (Haubold and Klein, 2000, 2002; D' Orazi-Porchetti et al., 2008; Klein et al., 2011; Lagnaoui et al., 2012) are generally considered as possible trackmakers. Because *Atreipus* is defined as a footprint with an associated manus, the specimen from Panlongqiao Village, that lacks this feature, cannot be assigned to this ichnogenus. Lockley et al. (2013) point out that *Pengxianpus cifengensis* cannot be attributed to the Late Triassic-Lower Jurassic ichnogenus *Eubrontes* because it lacks the asymmetry and

the pad configurations of the latter. We emphasize also that *Pengxianpus cifengensis* shows more slender digits and a higher divarication angle than *Eubrontes*, thereby resembling another large theropod footprint known as *Kayentapus*. *Kayentapus* was first described by Welles (1971) from the Lower Jurassic Kayenta Formation of Arizona and later identified also in Late Triassic-Lower Jurassic strata of North America and Europe (Weems, 1987, 1992; Gierliński and Ahlberg, 1994; Gierliński and Niedźwiedzki, 2005; Gierliński et al., 2004; Piubelli et al., 2005; Lockley et al., 2011). Other occurrences of *Kayentapus* in the Jurassic of southern Africa and China might be hidden behind possible synonyms published in the studies of Ellenberger (1972, 1974), Zhen et al. (1989), Li et al. (2010) and Xing et al. (2013). Lockley et al. (2013) provisionally retain *Pengxianpus cifengensis* as a valid ichnotaxon. We tentatively follow these authors, but we notice at least some similarities of *Pengxianpus* with *Kayentapus*: 1) slender shape of digits; 2) large digit divarication; 3) angle between digits III and IV larger than angle between II and III; 4) pronounced circular metatarsal-phalangeal pad on digit IV (see also our emended diagnosis). We do not synonymize these ichnotaxa here, considering the small sample containing a single well-preserved imprint. However, future studies may come to different conclusions. Further material from the Xujiahe Formation and the type locality, as well as a comparative study of tridactyl footprints including *Eubrontes* and ichnotaxa with a large digit divarication such as *Kayentapus*, *Pengxianpus* and others, is needed (see also below). For example *Anomoepus*, originally described from the Lower Jurassic of North America (see Olsen and Rainforth, 2003), and later identified also in Upper Triassic deposits (Niedźwiedzki, 2011), is another ichnogenus that shows widely divaricated digit traces. It is functionally tridactyl and sometimes shows a slight similarity with *Pengxianpus*. Trackways document facultative bipedal ornithischians. However, a characteristic feature in *Anomoepus* pes imprints is the metatarsal-phalangeal pad IV which is positioned in line with digit III at the posterior intersection of digits III and IV long axes, whereas in *Pengxianpus* it is only in line with digit IV.

Mammal-like tetrapod tracks

Material CFPC3, CFPC4, two isolated imprints and a few parallel scratches on the slab with the holotype of *Pengxianpus cifengensis*; CU 176.4, plaster cast of CFPC3 (Figs. 3, 6).

Locality and horizon The 3rd Member of the Xujiahe Formation, Late Triassic, Panlongqiao tracksite near Panlongqiao Village, Cifeng Town, Pengzhou City, Sichuan, China (Fig. 1).

Description Small tetradactyl to pentadactyl imprints of rounded overall-shape (1.9 and 2 cm in length and 1.7 and 2.2 cm in width). Digits are short and broad with robust rounded pads and blunt distal ends, rarely exhibiting an indistinct claw trace (Fig. 6A–B). Digit III is the longest, digits ?I and ?V shortest. In one imprint (Fig. 6C), digits are curved inward. The proximal ends of the digits form a posteriorly concave, semicircular arrangement followed by a small ?plantar/?palmar area (Fig. 6A–B).

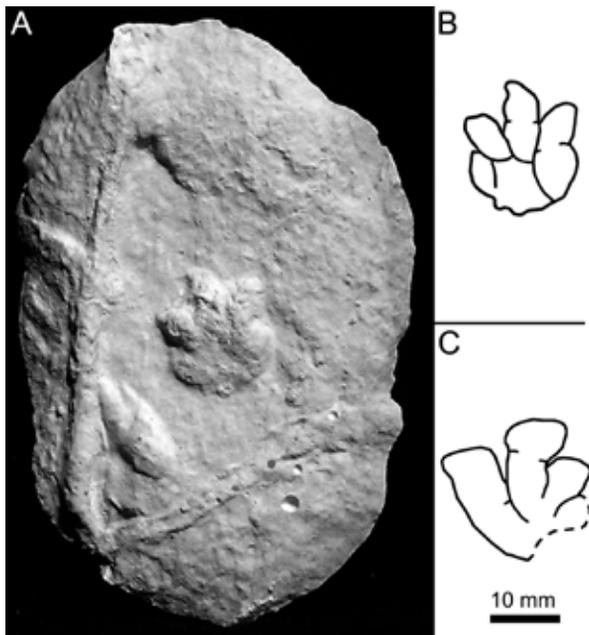


Fig. 6 Mammal-like tracks on *Pengxianpus cifengensis* holotype slab

A. photograph of silicon cast CU 176.4; B. sketch of A; C. sketch of second imprint; see Fig. 3 for overview

Discussion The imprints resemble those documented by Ellenberger (1972, 1974) from Lower Jurassic strata of the Stormberg Group in southern Africa. These were discussed by Lockley et al. (2004), together with similar mammal-like or synapsid trackways from the Upper Triassic-Lower Jurassic Wingate Formation of Colorado. Probable synapsid trackways (*Brasilichnium*) were described also from the Upper Triassic Redonda Formation (Chinle Group) (Lucas et al., 2010). The extremely broad shape of the digits of the Chinese material might be a preservational feature. Another possibility, that these are the manus imprints of dinosauriform or ornithischian trackmakers, attributable

to the ichnotaxa *Atreipus* or *Anomoepus* (Olsen and Baird, 1986; Olsen and Rainforth, 2003), can be excluded. The manus imprint in *Atreipus* and *Anomoepus* is characterized by a short and laterally spread trace of digit IV ($IV < II$), reflecting the dinosaurian reduction of digit IV. In contrast, the imprints described here have a long digit trace IV ($IV > II$). Therefore we relate them to mammal-like tetrapods. It is unclear if these isolated imprints are those of the pes or the manus. The curvature and the arrangement of digits suggest a left (Fig. 6A–B) and a right (Fig. 6C) imprint. The occurrence of these rare footprints in the Upper Triassic Xujiahe Formation is remarkable and indicates the presence of small mammal-like tetrapod groups in this part of Pangea. Presently, an attribution to early mammals cannot be proved conclusively.

4.2 Qingyi tracksite

Theropod footprints indet.

Material Two complete natural casts, catalogued as TQ.1 and 2 (TQ=Tianquan)(Fig. 7).

Locality and horizon The 3rd member of Xujiahe Formation, Late Triassic, Qingyi locality, Tianquan County, Ya'an City, Sichuan, China (Fig. 1).

Description The partial trackway consists of two successive pes imprints (11 and 10.5 cm in length) arranged in a narrow pattern with nearly parallel orientation along digit III. The imprints are tridactyl and approximately symmetrical along digit III which is the longest. Digits II and IV are short and thin, and the latter feature is probably due to preservational

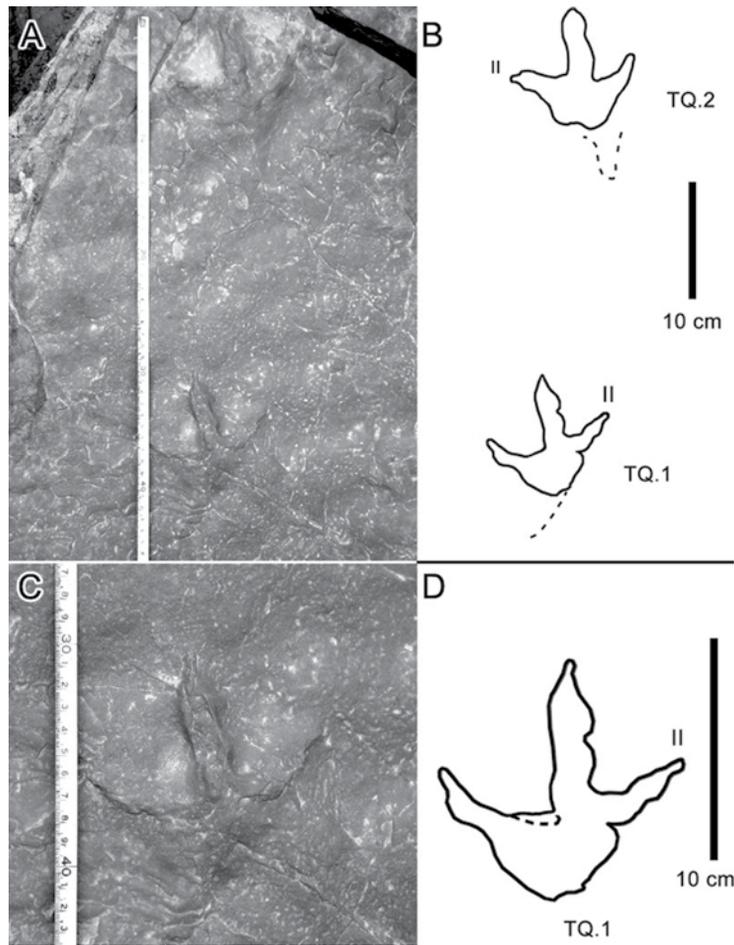


Fig. 7 Theropod footprints indet., partial trackway with two successive pes imprints (TQ.1–TQ.2)
A–B. overview of slab as photograph and sketch; C–D. detail of TQ.1

factors. Digits show a wide divarication with the angle between II–IV being up to 104° (Table 1). The broad overall-shape of the footprints is expressed in the length/width ratio that is 1.0. The proximal ends of digits are not distinctly separated from the short metatarsal-phalangeal portion, and the latter shows no preserved pads except for two posteriorly convex bulges at the proximal margin of TQ.2. They probably represent metatarsal-phalangeal pads II and IV. In TQ.1 the proximal margin of the footprint forms a posteriorly convex semicircular “heel”. In TQ.1 three rounded phalangeal pads are visible in digit III. Claws are indicated by slightly inward curved elongate traces with blunt distal ends.

Discussion Wang et al. (2005) considered TQ.1 and 2 to be tracks of coelurosaurs, and stated that this material basically coincides with the CDUT specimens of 1989. However, the divarication angles of CDUT specimens are slightly lower than those of TQ.1 and 2 (Wang et al., 2005).

The footprints from Qingyi are characteristic tridactyl theropod tracks. They are of small

size (11 cm in length). Compared with classical grallatorids they show a larger divarication angle II-IV: Qingyi specimen (87° – 104°), *Eubrontes* (25° – 40°), *Anchisauripus* (20° – 35°), and *Grallator* (10° – 30°) (Olsen et al., 1998). In *Pengxianpus cifengensis* this value is 69° . The feature seems to be anatomically based and cannot be explained by substrate conditions or the formation of undertracks only. A similar wide divarication of digits can be seen in typical bird footprints as in *Gruipeda* from the Santo Domingo Formation, now re-assigned to the Late Eocene (De Valais and Melchor, 2008; Melchor et al. 2013) or in *Trisauropodiscus* from the Late Triassic Molteno Formation of South Africa (Ellenberger, 1972). *Trisauropodiscus* was synonymized with *Gruipeda* by De Valais and Melchor (2008), based on the assumed Triassic age of the latter, but see Lockley and Gierliński (2006) for prior synonymy of North American *Trisauropodiscus* with *Anomoepus*. *Gruipeda* shows a different arrangement of pads and digit shape and often displays a trace of the hallux, differing from the grallatorid pattern seen in the Qingyi tracks. Another theropod ichnogenus with wide digit divarication is *Kayentapus* originally described from the Lower Jurassic Kayenta Formation of Arizona (Welles, 1971; see also Lockley et al., 2011 for overview). *Kayentapus* is defined as a large theropod footprint with slender digits of wide divarication, the angle between digits III and IV being larger than that between digits II and III. Also, a distinct and slightly separated metatarsal-phalangeal pad IV is present (Lockley et al., 2011). In the footprints from Qingyi, pads are only visible in digit III and the angles vary widely between the two imprints. The comparison with *Pengxianpus cifengensis* from the same stratigraphic unit reveals a similarity by the large digit divarication and the general outline of a symmetrical pes imprint with slender digits. However, it is questionable if the Qingyi footprints represent juvenile *Pengxianpus*. In ontogenetic growth series derived from footprints, juvenile individuals of theropod trackmakers show a smaller digit divarication compared with adults (Olsen et al., 1998). In contrast, small theropod footprints from the Xujiache Formation show a wider divarication compared with the large specimens.

The Late Triassic theropod footprint record is dominated by the typical *Grallator*. Rarely, other morphotypes such as *Kayentapus* occur. Presently, their differentiation is hindered by the lack of distinguishing anatomical features in tridactyl forms and their wide extramorphological variation. Therefore a provisional grouping in *Grallator*–*Anchisauripus*–*Eubrontes* plexus morphotype (low divarication angle, robust digits) on one hand and *Kayentapus*, *Pengxianpus*, Qingyi tracks morphotype (high divarication angle, slender digits) on the other is potentially useful. For a better ichnotaxonomic evaluation of *Pengxianpus* and the footprints from Qingyi more material is needed. Therefore we assign the Qingyi footprints tentatively to theropod footprints indet.

5 Conclusions

Theropod footprints from the Xujiache Formation of the Sichuan Basin are different from similar-sized Triassic-Jurassic ichnotaxa such as *Eubrontes* and *Grallator* by the larger digit

divarication and slender digit shape. A synonymy with *Kayentapus* is possible but cannot be proved presently. The ichnogenus *Pengxianpus* is preliminarily retained, and the smaller form from Qingyi is assigned to theropod footprints indet. Co-occurring mammal-like tetrapod footprints are the first evidence of such small tetrapods in the Triassic of southeastern Asia.

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四川盆地上三叠统最古老的兽脚类恐龙和似哺乳四足类动物足迹

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摘要: 四川盆地须家河组地层已发现了两处兽脚类恐龙足迹化石点, 其大小分别与实雷龙足迹(*Eubrontes*)和跷脚龙足迹(*Grallator*)相仿。其中与实雷龙足迹大小相近的足迹包括了两个连续的后足迹, 并构成行迹的一部分, 已被命名为磁峰彭县足迹(*Pengxianpus cifengensis*)。与粗壮的实雷龙足迹相比, 彭县足迹有着较细长的脚趾、保存尚清晰的趾垫、较宽的趾间角, 这些特征都与晚三叠世-早侏罗世的卡岩塔足迹(*Kayentapus*)相似。目前尚不能证明彭县足迹和卡岩塔足迹属于同物异名, 彭县足迹仍然被保留。两个足迹的部分区域都保存有皮肤纹理和多边形的鳞片印痕, 其中最清晰的是第二个彭县足迹第四趾的跖趾垫处。与跷脚龙足迹大小相近的、较小的兽脚类恐龙足迹也组成不甚完整的行迹。它们表现出的较宽趾间角与卡岩塔足迹和彭县足迹相似, 这里暂将其归入兽脚类足迹属种未定。彭县足迹的另一特别之处在于, 岩板表面还有着小的前/后足迹, 可归入似哺乳四足类动物足迹, 其形态类似于北美和南非三叠系-侏罗系地层产出的同类足迹。这是亚洲东南部似哺乳类足迹的首次报道。

关键词: 四川盆地, 晚三叠世, 须家河组, 兽脚类足迹, 似哺乳类足迹

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