古生物学报，**50**(4)：470－480(2011 年 12 月)
Acta Palaeontologica Sinica，**50**(4)：470－480(December，2011)

中国四川盆地南缘白垩纪中期的非鸟兽脚类行迹

邢立达[1，2)]　杰瑞德　D 哈里斯[3)]　杰勒德　D 杰尔林斯基[4，5)]　王伟铭[6)]　王智勇[7)]　李大庆[8)]

1) 阿尔伯塔大学生物科学系，加拿大埃德蒙顿 T6G 2E9，Xinglida@gmail.com；
2) 中国科学院脊椎动物进化系统学开放实验室，北京 100044；
3) 迪克西州立学院自然科学系，美国犹他 84770；
4) 侏罗纪公园，波兰 奥斯特罗维茨 4，27-400；
5) 波兰地质研究所，波兰华沙 4，00-975；
6) 中国科学院南京地质古生物研究所，江苏南京 210008；
7) 赤水市国土资源局，贵州赤水 564700；
8) 甘肃地质博物馆，甘肃兰州 730040

提要　描述中国贵州赤水地区白垩纪中期窝头山组(夹关组)宝源足迹点的七道非鸟兽脚类行迹。尽管统计的样本不甚充足，但足迹所在岩层的孢粉初步分析结果表明其时代可新至晚白垩世(最晚可晚于 Cenomanian 阶)。这批足迹被归入似和平河足迹未定种(cf. *Irenesauripus* isp.)，大多数足迹的跖趾垫区域保存了不同大小的跖骨垫。一些延长的趾痕则可能暗示着其造迹者的第二趾拥有一个超过其它趾的长爪。足迹化石显示窝头山组(夹关组)所含动物群缺乏蜥脚类，而以兽脚类和鸟脚类为主。

关键词　似和平河足迹未定种　窝头山组　中白垩世　赤水地区　四川盆地

MID-CRETACEOUS NON-AVIAN THEROPOD TRACKWAYS FROM THE SOUTHERN MARGIN OF THE SICHUAN BASIN，CHINA

XING Li-da[1，2)]，Jerald D HARRIS[3)]，Gerard D GIERLIŃSKI[4，5)]，
WANG Wei-ming[6)]，WANG Zhi-yong[7)] and LI Da-qing[8)]

1) *Department of Biological Sciences，University of Alberta，*11145 *Saskatchewan Drive，Edmonton，Alberta T6G 2E9，Canada，Xinglida@gmail.com*；
2) *Key Laboratory of Evolutionary Systematics of Vertebrates，Chinese Academy of Sciences，PO Box* 643，*Beijing* 100044，*China*；
3) *Physical Sciences Department，Dixie State College，*225 *South* 700 *East，St. George，Utah* 84770，*USA*；
4) *JuraPark，ul. Sandomierska* 4，27-400 *Ostrowiec Świętokrzyski，Poland*；
5) *Polish Geological Institute，Rakowiecka* 4，00-975 *Warsaw，Poland*；
6) *Nanjing Institute of Geology and Paleontology，Chinese Academy of Sciences，Nanjing* 210008，*China*；
7) *Chishui Bureau of Land and Resources，Chishui，Guizhou* 564700，*China*；
8) *Gansu Geological Museum，Lanzhou* 730040，*China*

Abstract　Here we describe seven non-avian theropod trackways from the Baoyuan track site in the mid-Cretaceous Wotoushan Formation (Jiaguan Formation) in the Chishui area，Guizhou Province，China. Preliminary palynological analysis indicates Late Cretaceous age not earlier than Cenomanian at the oldest. Footprints at the site pertain to cf. *Irenesauripus* isp. Most tracks preserve partial metatarsal pads that are not distinct from their respective metatarsophalangeal regions. Several elongate digit impressions may indicate that digit II of the track maker possessed a long claw，longer than on any of the other digits. Most notably，the Wotoushan (Jiaguan) fauna lacks sauropods and

收稿日期：2011-05-17

is dominated instead by theropods and ornithopods.

Key words　cf. *Irenesauripus* isp., Wotoushan Formation, mid-Cretaceous, Chishui area, Sichuan Basin

1　INTRODUCTION

The Sichuan Basin is world-wide known Mesozoic terrestrial strata and the fossil vertebrate faunas they yield. Dinosaur fossils from the Sichuan Basin are predominately Jurassic in age (Peng *et al.*, 2005); Cretaceous dinosaur fossils thus far consist only of tracks from the Jiaguan Formation (Chen *et al.*, 2006).

The Chishui region spans the far northwest of Guizhou Province and southern border of the Sichuan Basin and is famous for pseudo-karst Danxia landforms. Outcrops consist of red, terrestrial strata of Cretaceous age (Peng, 2000). These strata are correlated with those in Qijiang County, Chongqing, roughly 100 km away, where abundant ornithopod, theropod, and possibly ankylosaurian dinosaur tracks have been discovered (Xing *et al.*, 2007). Numerous of dinosaur tracks were also recently discovered in Chishui City, Guizhou Province.

An oral tradition that is popular among the residents at Baoyuan Township, 20 km southwest of Chishui City, centers on the "Xian Ji" (which translates as "celestial chicken") footprints left by a mythical bird in the forest. These tracks are described as having three, forward-pointing toes and one backward-pointing toe, all with big claws. The Xian Ji tracks are in an area now encompassed in the Chishui *Alsophila* (an endangered tree fern) National Nature Reserve of Guizhou Province.

In 1995, Mr. Li Chang-fu, from the Renhuai City National Tax Bureau, Chishui Municipal Environmental Protection Bureau, went to the site and made the first modern report of the dinosaur tracks at what is now called the Baoyuan track site. In August 2009 and April 2010, authors were invited to investigate the Baoyuan track site along with personnel from the Chishui Bureau of Land and Resources Baoyuan Land Office, and the results of that investigation are reported here.

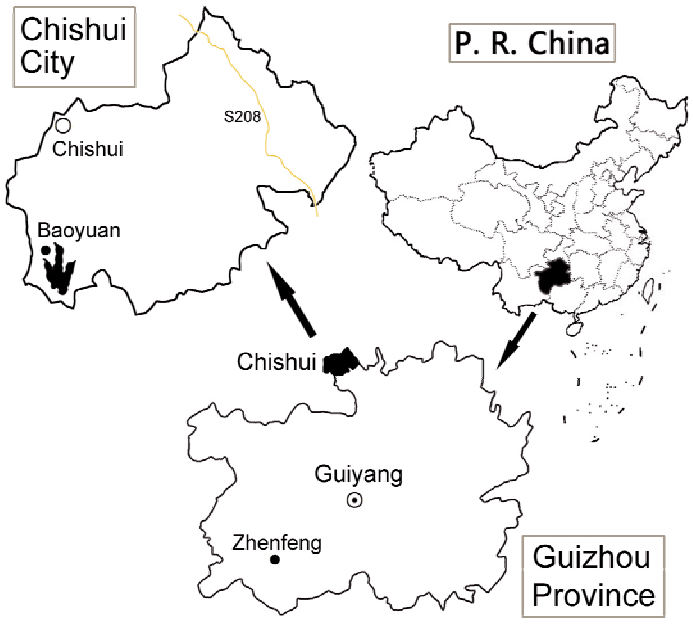

Fig. 1　Geographic map indicating location (footprint icon) of the Baoyuan track site in Baoyuan Township, Guizhou Province, China

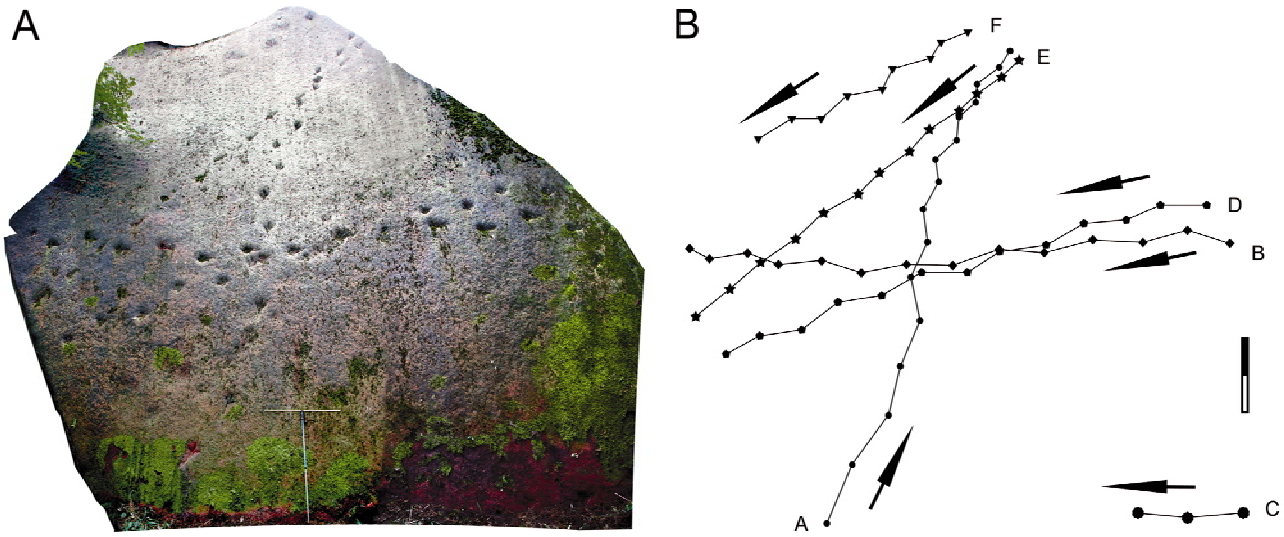

Fig. 2 Trackways from Baoyuan track site (map indicates the general track distribution, but not the real distances, among individual footprints)

A: Photographs; B: Schematic drawings. Scale bar = 1 m.

2 GEOLOGICAL SETTING

2.1 The Wotoushan Formation (Jiaguan Formation)

Cretaceous strata in Guizhou Province outcrop only sporadically. The fluvial deposits in the Chishui area and the Sichuan Basin belong to the Jiading Group (Gu, 1962), which is the primary unit forming Danxia landforms. Large blocks weathered along joints litter the floors of canyons between cliff outcrops. The dinosaur tracks discussed here were discovered on one such block.

Currently, the Jiading Group in Guizhou Province is divided into the lower Wotoushan Formation and the upper Sanhe Formation. The Wotoushan Formation was named by the aerial survey team of the Sichuan Bureau of Geology in 1980. However, the Guizhou Bureau of Geology and Mineral Resources (1981, 1987) subsequently referred the unit to the Jiaguan Formation and subsequently to the first member of the Jiaguan Formation. Dong (1997) resurrected the name Wotoushan Formation for the nationwide stratigraphic division and correlation.

In the Chishui area, the Wotoushan Formation (Jiaguan Formation) in comprised of dark magenta to brick red colored thick-bedded fine-grained quartz sandstones with dark magenta mudstone interbeds; the base of the unit is conglomeratic. These strata were deposited in an upstream, braided river facies of a broad, alluvial plain at the border of an inland lake basin (Dong, 1997).

The Wotoushan Formation (Jiaguan Formation) overlies the Penglaizhen Formation. The age of the Wotoushan Formation has been considered late Early Cretaceous (Dong, 1997). Since the Jiaguan Formation was first recognized as a distinct unit, its reported age has varied between Early Cretaceous (Lockley *et al.*, 2008), "middle" Cretaceous (Hao *et al.*, 1984, 2000), and Late Cretaceous (Chen *et al.*, 2006). Li (1995) and Gou and Zhao (2001) also provided broad age ranges within the Cretaceous: 85-117 Ma and Valanginian-Santonian, respectively.

2.2 Palynological analysis

Palynomorphs can be important index fossils in the Cretaceous, so a palynological analysis was performed by one of us (Wang Wei-ming). Only a few poorly preserved pollen grains were obtained from the track layer, so they could only be identified to genus (Table 1). Nevertheless, they reveal useful information. Most of the palynomorph genera recovered (*Leiotriletes*, *Polypodiisporites*, *Deltoidospora*, *Abietineaepollenites*, *Pinuspolle-*

nites, and *Cedripites*) have broad chronostratigraphic distributions (Song *et al.*, 1999, 2000) that provide no age control for the track-bearing unit. Some however, are more restricted. For example: *Triporoletes* is limited to the Cretaceous (Song *et al.*, 2000); *Taxodiaceaepollenites* is widely distributed in the Early Cenozoic, but is rare in the Cretaceous (Song *et al.*, 1999); the oldest occurrence of *Quercoidites* is in the Cenomanian of Songliao Basin (Gao *et al.*, 1999), otherwise being widely distributed in Early Cenozoic strata around China (Song *et al.*, 2004). *Cupuliferoidaepollenites* similarly has a Cretaceous-Tertiary distribution, though global rather than just in China (Song *et al.*, 2000). The earliest occurrences of *Myricipites* are in the Upper Cretaceous Furao Formation of Heilongjiang Province (Liu, 1983) and the Kukebai Formation in the Tarim Basin of Xinjiang Province (Wang *et al.*, 1990). Thus although Baoyuan palynomorphs are not present in statistically significant quantities, they provide Late Cretaceous age signal, concurring with previous age assignments of the Wotoushan Formation (Jiaguan Formation) in Guizhou Province.

Table 1　Spores and pollen grain genera recovered from the Baoyuan track site

Plantae	Palynogenus	Num.
Pteridophyta	*Leiotriletes*	7
	Triporoletes	1
	Polypodiisporites	2
	Deltoidospora	1
Gymnospermae	*Abietineaepollenites*	2
	Pinuspollenites	15
	Cedripites	5
	Taxodiaceaepollenites	2
Angiospermae	*Quercoidites* (large type)	3
	Cupuliferoidaepollenites	2
	Myricipites	1

3　ICHNOTAXONOMY

Theropoda Marsh, 1881

***Irenesauripus* Sternberg, 1932**

cf. *Irenesauripus* isp.

Material　Seventy-two natural moulds of tridactyl and tetradactyl bipedal tracks in seven trackways (BYA-BYG) from the Baoyuan track site. Replicas of BYA1-3 are stored at the Huaxia Dinosaur Tracks Research and Development Centre, Geological Museum of Gansu (HDT), catalogued HDT. BYA1-3. The original tracks remain in the field.

Type locality and horizon　Wotoushan Formation (Jiaguan Formation), mid-Cretaceous. Baoyuan track site, Chishui area, Guizhou Province, China.

Description　Trackways A-F consist of different numbers of tracks (Table 2). All seven trackways are distributed across a single surface of a fallen, 11 m-high, 14 m-wide block of Wotoushan Formation (Jiaguan Formation) sandstone (Fig. 2). Another fragmentary trackway (trackway G; Table 2) was discovered on a separate block in the same vicinity. Among the tracks, those in trackway A are the best preserved. The depths of the tracks range from 3. 5-5. 0 cm. The pace angulation of BYA1-3 is 165° and exhibits no rotation with respect to the trackway axis.

Track BYA3 (Fig. 3) serves as an exemplar of the morphology of the tracks. Digit III projects the farthest cranially, followed by digits IV, II, and I. Due to the soft, semi-wet sediments in which the tracks were made, and exposure to later weathering by vegetation, the track morphology is unusual. It exhibits of extramorphological, substrate-based features rather than reflecting track maker pedal morphology. However, the deep, regular, concave digit impressions appear to retain pad impressions that probably have a formula of 2-2-4-4-x. Each digit has a sharp claw mark; the one on digit III is the clearest and longest. In general, the digits have wide divarication angles; the angle between digits III and IV is slightly greater than that between digits II and III. Distinct, convex borders demarcate the metatarsophalangeal region and metatarsal pad. The distal end of the terminal

metatarsal ("heel") impression shallows and expands transversely.

The mean length : width ratio calculated from BYA1-13 (Fig. 4) is 1.13 : 1. BYA1-4 each preserve distinct digit I impressions. Only BYA11-BYA13 preserve long "heel" impressions like those of BYA2 (Fig. 3) and BYA3, which is probably a function of changing sediment viscosity. However, the other tracks preserve partial metatarsal pads that are not distinct from their respective metatarsophalangeal regions. In all tracks, the distal ends of the impressions of digits I-III are relatively deep. For most tracks, digit II is generally deeper than digit IV.

Discussion Tridactyl and tetradactyl tracks (including a hallux impression) in which the longest digit is digit III, such as those at the Baoyuan track site, are typically made by bipedal theropods. The BYA tracks have low length/width ratios (1.13 : 1) and wider angles between digits (total divarication varies between 45° and 78°) than those of either *Grallator* or *Eubrontes*. The large digit divarication angles accord with some characteristics of *Kayentapus* (Gierliński, 1991, 1996; Gierliński and Ahlberg, 1994; Piubelli *et al.*, 2005) and *Irenesauripus* (Sternberg, 1932; McCrea, 2000; Gangloff *et al.*, 2004; Gierliński *et al.*, 2008). However, most of the currently recognized species of *Kayentapus* and *Irenesauripus*, like *K. hopii* (Welles, 1971), *K. minor* (Lull, 1953; Weems, 1992), *K. hailiutuensis* (Li *et al.*, 2010), and *I. mclearni* and *I. acutus* (Sternberg, 1932) lack hallux impressions. Employing the method of Weems (1992) to discriminate *Kayentapus* footprints at the ichnospecific level (Gierliński, 1996; Gierliński *et al.*, 2004; Piubelli *et al.*, 2005), the dimensional ratios of BYA2 are: te/fw = 0.41 and (fl-te)/fw = 0.51; the ratios of BYA3 are: te/fw = 0.57 and (fl-te)/fw = 0.52. Thus, they are located outside the known range of *Kayentapus* (Fig. 5).

Amongst Cretaceous theropod ichnotaxa, the Baoyuan tracks seem closest to *Irenesauripus sensu* Gangloff *et al.* (2004) and Gierliński *et al.* (2008). Characteristics supporting this attribution are: the majority of divarication angles between digits III and IV are greater than between digits II and III, and phalangeal pad impressions are typically weak to absent (Gangloff *et al.*, 2004). However, other *Irenesauripus* tracks differ from the Baoyuan material in their larger sizes and lack of hallux impressions. Thus, the Baoyuan specimens can at best be referred to as cf. *Irenesauripus* isp.

Amongst other Chinese tracks, *Jialingpus* (Zhen *et al.*, 1983), *Eubrontes*-like tracks (Lockley *et al.*, 2003), and the Baoyuan trackways possess similar metatarsal pads. Zhen *et al.* (1989) considered *Jialingpus yuechiensis* tracks similar to *Anomoepus*, but their highly projected third toes and narrow divarication angles led Gierliński (1994), Lockley *et al.* (2003), and Gierliński *et al.* (2009) to attribute them to a theropod. *Jialingpus* is similar in size to the Baoyuan tracks, but the divarication angles between digits II and IV of the Baoyuan tracks (45°-78°) are larger than the 44°-52° angles of *Jialingpus* (Xing *et al.*, 2011). However, the effects imposed by substrate conditions on the Baoyuan tracks may be more substantial than those of *Jialingpus*. Furthermore, the length : width ratios of *Jialingpus* tracks are 1.86 : 1, much larger than the 1.13 : 1 ratio of tracks from Baoyuan trackway A. Also, the hallux of *Jialingpus* extends farther outward than the outermost margin of digit II, which is not true for the Baoyuan tracks. Pad I of digit II of *Jialingpus* is larger than the pads of digit IV, and almost as large as the metatarsophalangeal pad, unlike the Baoyuan tracks. Noticeably, in *Jialingpus* tracks at the Huanglong track site in Sichuan Province, only Beijing Natural History Museum specimen BNHM-SCFP 24 preserves both a metatarsal pad and hallux impression. In the Baoyuan trackways, both a metatarsal pad and a hallux impression are continuously present across several trackways.

The *Eubrontes*-like track discussed by Lockley *et al.* (2003) was attributed to a crouching theropod, but it is poorly preserved and therefore a dif-

ficult to compare.

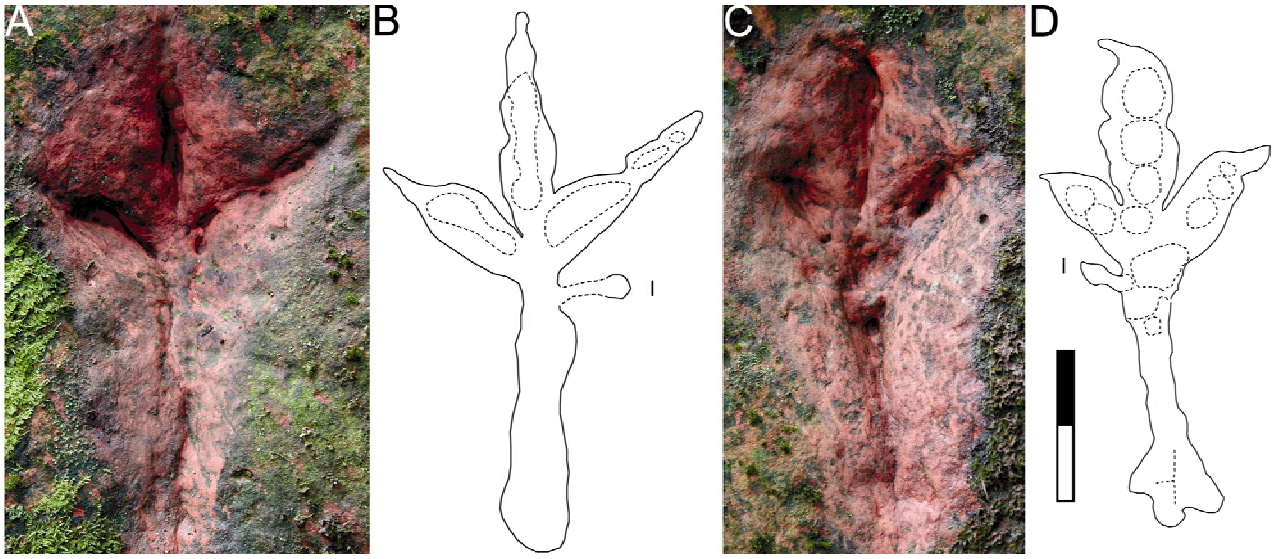

Fig. 3　Baoyuan tracks BYA2 and BYA3

A, C: Photographs; B, D: Outline drawings. Scale bar = 10 cm.

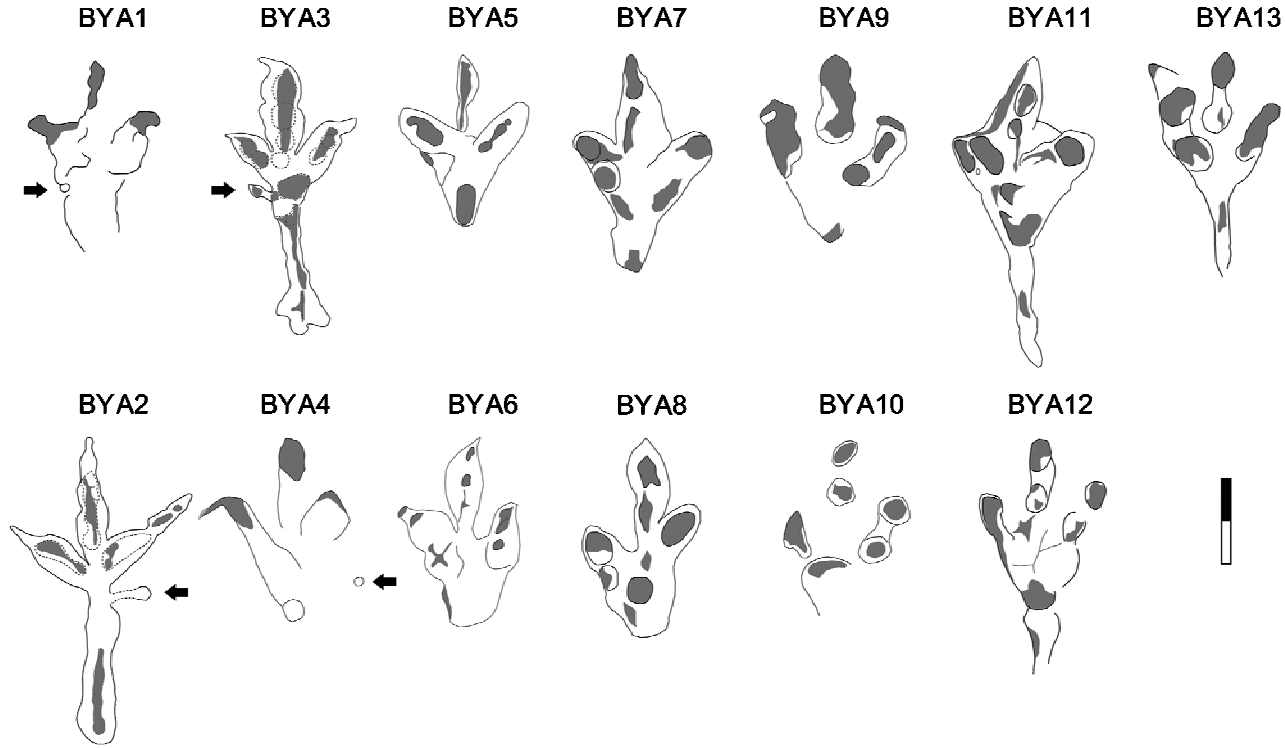

Fig. 4　Outline drawings of tracks A1-A13 from trackway BYA

Arrows indicates digit I; dark shading indicates deeper parts of the tracks. Scale bar = 10 cm.

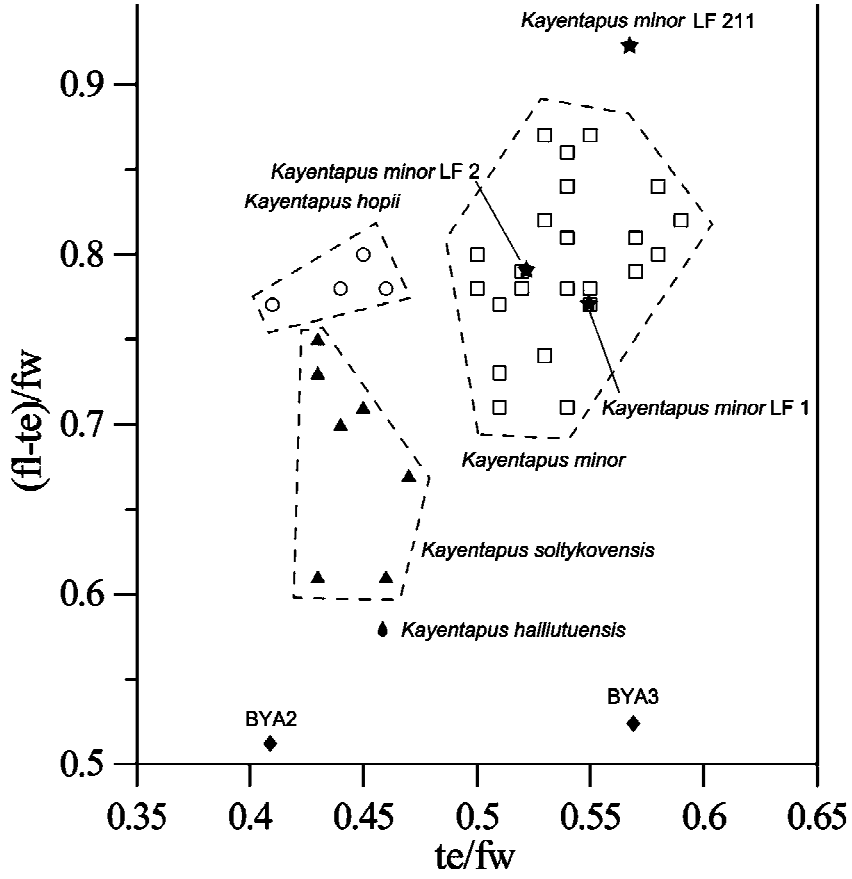

Fig. 5 Graphic separation of Baoyuan specimens according to the method of Weems (1992), after Gierliński (1996), Gierliński *et al.* (2004), and Xing *et al.* (in press)

For the explanation of *te*/*fw* and (*fl-te*)/*fw* see Weems (1992).

Table 2 The numbers of tracks in Baoyuan track site trackways A-G

Trackway	A	B	C	D	E	F	G
Number of tracks	16	14	3	13	13	9	4

Table 3 Measurements (in cm; ° as noted) of tracks from Baoyuan track site trackway A

Number	R/L	ML	MW	II	III	IV	MP	II-III	III-IV	II-IV	SL	PL	L/W
BYA1	R	15.46	15.19	5.78	7.14	5.64	6.71	26°	24°	50°	160	81	1.02
BYA2	L	19.49	21.52	13.35	13.06	10.41	16.63	39°	39°	78°	155	84	0.91
BYA3	R	16.90	15.53	5.99	11.47	7.60	15.94	32°	29°	62°	155	77	1.09
BYA4	L	18.94	15.96	6.65	10.63	7.85	2.43	17°	28°	45°	152	80	1.19
BYA5	R	15.39	14.86	7.20	8.97	7.45	4.91	30°	27°	57°	155	90	1.04
BYA6	L	17.19	13.70	8.08	11.05	7.46	5.11	24°	29°	53°	150	80	1.25
BYA7	R	18.09	15.72	7.85	11.21	7.87	7.60	23°	30°	53°	151	80	1.15
BYA8	L	19.26	13.06	6.31	10.87	7.59	3.96	20°	33°	53°	150	80	1.47
BYA9	R	17.75	16.19	9.17	10.48	9.06	4.39	27°	27°	54°	130	70	1.10
BYA10	L	13.81	12.65	8.76	7.82	5.55	6.56	25°	27°	52°	145	75	1.09
BYA11	R	18.00	15.53	7.14	9.90	8.02	18.98	36°	24°	60°	140	80	1.16
BYA12	L	16.50	14.08	7.93	8.59	7.06	11.14	25°	27°	52°	-	70	1.17
BYA13	R	17.49	15.82	14.09	9.61	7.83	8.91	25°	23°	48°	-	-	1.11

R/L: right/left; ML: maximum length (including the metapodium); MW: maximum width measured between the tips of digits II and IV; II: length of digit II; III: length of digit III; IV: length of digit IV; MP: length of metatarsal pad; II-III: angle between digits II and III; III-IV: angle between digits III and IV; SL: stride length; PL: pace length; L/W: ratio of maximum length/maximum width.

3.2 Unusual Digit II Claw Impression

In BYA2 (Fig. 3), the lengths and widths of each digit, as well as the divarication angles between digits II and IV are all noticeably larger than in other tracks of the Baoyuan sample—only BYA13 (Fig. 4) and tracks in trackway BYG (Fig. 6) possess similar digit lengths. The multiple instances of this morphology, however, indicate that it does not reflect pathologic or otherwise deformed feet. These elongate digit impressions may represent drag marks, which can be made in muddy sediments or at slower walking speed. Drag marks, however, are normally made as are the short claw drag marks preserved in Early Cretaceous *Grallator* specimens from Sihetun, Liaoning Province (Xing *et al.*, 2009a).

These elongate digit impressions may indicate that digit II of the BYA and BYG track maker possessed a long claw (Fig. 7), longer than on any of the other digits. The digit II claw may have been lowered only occasionally in such a way as to leave marks, when the track maker progressed through muddy sediment. This hypothetical pedal morphology for the BYA track resembles that of *Cariama cristata* (Red-legged Seriema). *Cariama cristata* had an extensible second pedal claw that is held off the ground, though the majority of the carrying digit remains in contact with the substrate. *Cariama cristata* used its beak and claws to dismember small vertebrates (Miranda-Ribeiro, 1938; Redford, 2007). This characteristic of the Baoyuan tracks differs from deinonychosaur tracks (Li *et al.*, 2007; Xing *et al.*, 2009b), which preserve impressions only of the proximal ends of their digits II, because deinonychosaurs held most of digit II off the ground, not just the ungual. Digit II of the BYA and BYG track maker contacted the ground except for the most distal, ungual-bearing end.

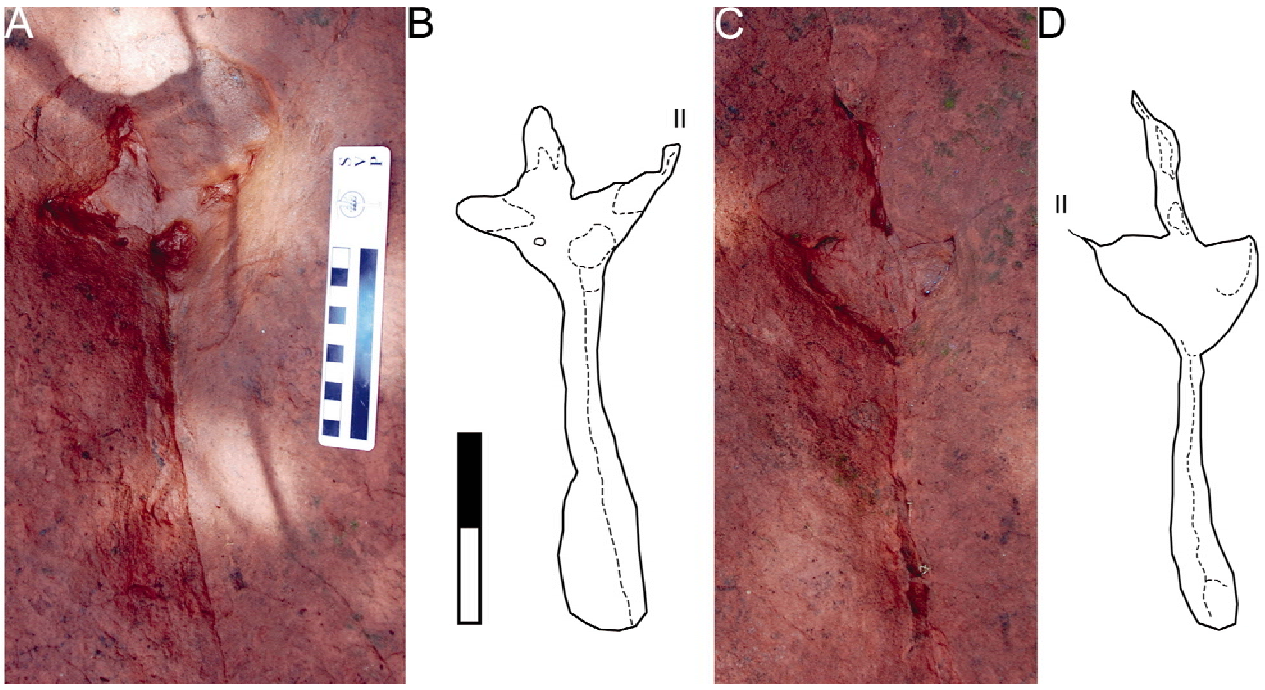

Fig. 6　Baoyuan tracks BYG2 and BYG3

A, C: Photographs; B, D: Outline drawings. Scale bar = 10 cm.

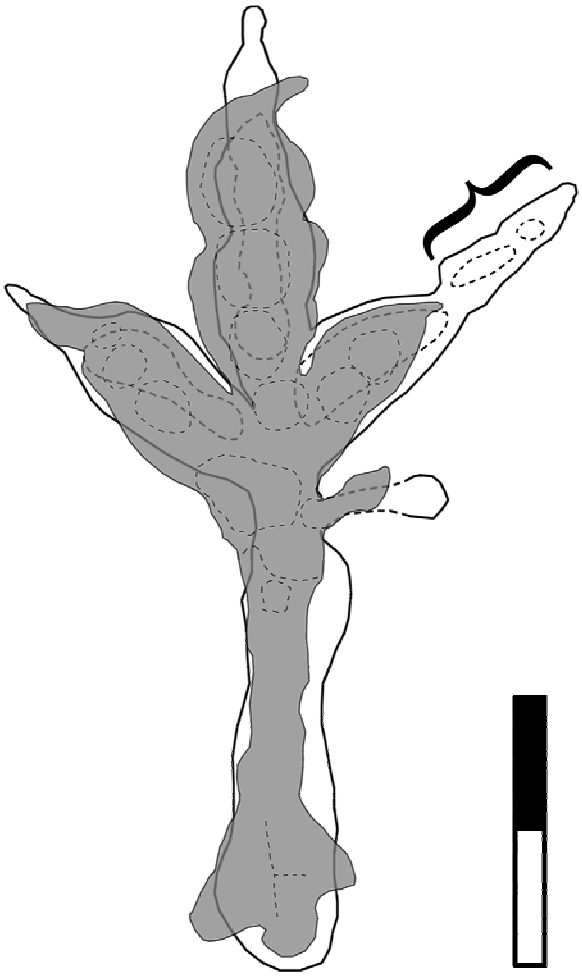

Fig. 7 Overlapping schematic diagrams of BYA3 (gray) and BYA2 (white)

Brachet indicates inconsistent region. Scale bar = 10 cm.

4 NON-AVIAN AND AVIAN DINOSAUR TRACKS FROM WOTOUSHAN FORMATION (JIAGUAN FORMATION) OF THE SICHUAN BASIN

Track sites are currently known from the Wotoushan Formation (Jiaguan Formation) in the Sichuan Basin at Guanyingchong (Yibin City, Sichuan), Emei (Emei City, Sichuan), Lotus (Qijiang County, Chongqing), as well as from Baoyuan (this text). Tracks from these formations include:

(1) Small theropod tracks: *Grallator emeiensis* (Zhen *et al.*, 1995), *Minisauripus chuanzhuensis* (Zhen *et al.*, 1995; Lockley *et al.*, 2008), *Velociraptorichnus sichuanensis* (Zhen *et al.*, 1995; Xing *et al.*, 2009b), *Wupus agilis* (Xing *et al.*, 2007).

(2) Medium-size theropod tracks: *Yangtzepus yipingensis* (Young, 1960; Xing *et al.*, 2009c), cf. *Irenisauripus* isp. (this text).

(3) Medium-size to large ornithopod tracks: *Iguanodontipus xingfuensis* (Zhen *et al.*, 1995; Xing *et al.*, 2009c), *Caririchnium lotus* (Xing *et al.*, 2007); *Laoyingshanpus torridus* (Xing *et al.*, 2007);

(4) Ankylosaur tracks: *Qijiangpus sinensis* (Xing *et al.*, 2007).

(5) Bird tracks: *Aquatilavipes sinensis* (nomen dubium) (Zhen *et al.*, 1995; Lockley *et al.*, 1992, 1994; Lockley and Harris, 2010).

These tracks suggest that during the deposition of Wotoushan Formation (Jiaguan Formation), a diverse dinosaur fauna lived in present-day southern China and that this fauna differed substantially from the Early Jurassic *Lufengosaurus* fauna, Middle Jurassic *Shunosaurus* fauna, and Late Jurassic *Mamenchisaurus* fauna from the Sichuan Basin (Peng *et al.*, 2005). The Wotoushan (Jiaguan) fauna lacks sauropods and is dominated instead by theropods and ornithopods.

Acknowledgements We thank Philip J. Currie (University of Alberta, Edmonton, Alberta, Canada), You Hailu (Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China), and Li Rihui (Qingdao Institute of Marine Geology, China Geological Survey, Qingdao, China) for their critical comments and suggestions on early drafts of this paper. Thanks also to Pan Wengqing, Zhang Xiaobo (Chishui Bureau of Land and Resources, Chishui, China), Li Guanghua (Baoyuan Township Government), and Zhong Xiaoyong, Tang Laibin (Office of Baoyuan Township Bureau of Land and Resources) for their participation in field research. Thanks to the Chicheng County Bureau of Land and Resources, who provided logistic support.

References

Chen P J, Li J, Matsukawa M, Zhang H *et al.*, 2006. Geological ages of dinosaur-track-bearing formations in China. Cretaceous Research, **27**(1): 22—32.

Dong Wei-ping (董卫平), 1997. Stratigraphy (Lithostratic) of Guizhou Province. Multiple Classification and Correlation of the Stratigraphy of China 52. Wuhan: China University of Geosciences Press. 1—306 (in Chinese).

Gangloff R S, May K C, Storer J E, 2004. An Early Late Cretaceous dinosaur tracksite in Central Yukon Territory, Canada. Ichnos, **11**: 299—309.

Gao Rui-qi (高瑞祺), Zhao Chuan-ben (赵传本), Qiao Xiu-yun (乔秀云) *et al.*, 1999. Cretaceous Oil Strata Palynology from Songliao Basin. Beijing: Geological Publishing House. 1—373 (in Chinese with English abstract).

Gierliński G, 1991. New dinosaur ichnotaxa from the Early Jurassic of the Holy Cross Mountains Poland. Palaeogeography, Palaeoclimatology, Palaeoecology, **85**: 137—148.

Gierliński G, 1994. Early Jurassic theropod tracks with the metatarsal impressions. Przegląd Geologiczny, **42**: 280—284.

Gierliński G, 1996. Dinosaur ichnotaxa from the Lower Jurassic of Hungary. Geological Quarterly, **40**: 119—128.

Gierliński G, Ahlberg A, 1994. Late Triassic and Early Jurassic dinosaur footprints in the Höganäs Formation of southern Sweden. Ichnos, **3**: 99—105.

Gierliński G, Niedźwiedzki G, Nowacki P, 2009. Small theropod and ornithopod footprints in the Late Jurassic of Poland. Acta Geologica Polonica, **59**: 221—234.

Gierliński G, Niedźwiedzki G, Pieńkowski G, 2004. Tetrapod track assemblage in the Hettangian of Sołtyków, Poland, and its paleoenvironmental background. Ichnos, **11**: 195—213.

Gierliński G, Ploch I, Gawor-Biedowa *et al.*, 2008. The first evidence of dinosaur tracks in the Upper Cretaceous of Poland. Oryctos, **8**: 107—113.

Gou Zong-hai (苟宗海), Zhao Bing (赵　兵), 2001. The Cretaceous and Tertiary systems in Dayi and Chongzhou regions, Sichuan. Journal of Stratigraphy (地层学杂志), **25** (1): 28—33, 62 (in Chinese with English summary).

Gu Zhi-wei (顾知微), 1962. The Jurassic and Cretaceous of China. Beijing: Science Press. 1—84 (in Chinese).

Guizhou Bureau of Geology and Mineral Resources (贵州省地质矿产局), 1987. Regional Geology of Guizhou Province. Beijing: Geological Publishing House. 1—698 (in Chinese).

Guizhou Bureau of Geology and Mineral Resources (贵州省地质矿产局), 1981. Geological Summary of Regional Geology of Guizhou Province, Geologic Map Scale 1∶500 000 (in Chinese).

Hao Yi-chun (郝诒纯), Su De-ying (苏德英), Yu Jing-xian (余静贤) *et al.*, 2000. Stratigraphical Lexicon of China——The Cretaceous. Beijing: Geological Publishing House. 1—124 (in Chinese with English summary).

Hao Yi-chun, Guan Shao-ceng, 1984. The Lower-Upper Cretaceous and Cretaceous-Tertiary boundaries in China. Bulletin of the Geological Society of Denmark, **33**: 129—138.

Li Yuan-lin (李元林), 1995. Daxi conglomerate and its geological time. Journal of Chengdu University of Technology (成都理工学院学报), **22** (2): 11—14 (in Chinese with English summary).

Li Jian-Jun (李建军), Bai Zhi-qiang (白志强), Lockley M G *et al.*, 2010. Dinosaur tracks in Wulatezhongqi, Inner Mongolia. Acta Geologica Sinica (地质学报), **84** (5): 723—742 (in Chinese with English abstract).

Li Ri-hui, Lockley M G, Makovicky P J *et al.*, 2007. Behavioral and faunal implications of Early Cretaceous deinonychosaur trackways from China. Die Naturwissenschaften, **95** (3): 185—191.

Liu Mu-ling (刘牧灵), 1983. The Late Upper Cretaceous to Palaeocene spore pollen assemblages from the Furao area, Heilongjiang Province. Bulletin of the Shenyang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences (中国地质科学院沈阳地质矿产研究所所刊), **7**: 99—132 (in Chinese with English abstract).

Lockley M G, Harris J D, 2010. On the trail of early birds: a review of the fossil footprint record of avian morphological and behavioral evolution. *In*: Ulrich P K, Willett J H (eds.), Trends in Ornithology Research. Hauppauge: Nova Publishers. 1—63.

Lockley M G, Hunt A P, Meyer C A, 1994. Vertebrate tracks and the ichnofacies concept: implications for paleoecology and palichnostratigraphy. *In*: Donovan S (ed.), The Paleobiology of Trace Fossils. Chichester: John Wiley and Sons. 241—268.

Lockley M G, Kim J Y, Kim K S *et al.*, 2008. *Minisauripus*——the track of a diminutive dinosaur from the Cretaceous of China and South Korea: implications for stratigraphic correlation and theropod foot morphodynamics. Cretaceous Research, **29** (1): 115—130.

Lockley M G, Matsukawa M, Li J, 2003. Crouching theropods in taxonomic jungles: Ichnological and ichnotaxonomic investigations of footprints with metatarsal and ischial impressions. Ichnos, **10**: 169—177.

Lockley M G, Yang S Y, Matsukawa M *et al.*, 1992. The track record of Mesozoic birds: evidence and implications. Philosophical Transactions (Biological Sciences), **336** (1277): 113—134.

Lull R S, 1953. Triassic life of the Connecticut Valley. Bulletin of the Connecticut State Geology Natural History Survey, **181**: 1—331.

McCrea R T, 2000. Dinosaur footprints in the Lower Cretaceous (Albian) Gates Formation of Alberta, Canada: Their use in palaeobiology and palaeoenvironmental interpretation. Paleontological Society of Korea Special Publication, **4**: 169—178.

Miranda-Ribeiro A D E, 1938. A seriema. Revista do Museu Paulista, **23**: 39—90.

Peng Guang-zhao (彭光照), Ye Yong (叶　勇), Gao Yu-hui (高玉辉) *et al.*, 2005. Jurassic Dinosaur Faunas in Zigong. Chengdu: Peoples' Publishing House of Sichuan Province. 1—236 (in Chinese with English summary).

Peng Hua(彭 华),2000. A survey of the Danxia landform research in China. Scientia Geographica Sinica(地理科学),(3):203—211(in Chinese).

Piubelli D,Avanzini M,Mietto P,2005. The Early Jurassic ichnogenus *Kayentapus* at Lavini di Marco ichnosite(NE Italy). Global distribution and palaeogeographic implications. Bollettino della Società Palaeontologica Italiana,**124**:259—267.

Redford K H,Peters G,2007. Notes on the biology and song of the Red-legged Seriema(*Cariama cristata*). Journal of Field Ornithology,**57**(4):261—269.

Song Zhi-chen(宋之琛),Shang Yu-ke(尚玉珂),Liu Zhao-sheng(刘兆生) *et al.*,2000. Fossil Spores and Pollen of China. Vol 2. The Mesozoic Spores and Pollen. Beijing:Science Press. 1—710(in Chinese with English summary).

Song Zhi-chen(宋之琛),Wang Wei-ming(王伟铭),Huang Fei(黄翡),2004. Fossil pollen records of extant Angiosperms in China. The Botanical Review(植物审查),**70**(4):425—458(in Chinese with English summary).

Song Zhi-chen(宋之琛),Zheng Ya-hui(郑亚惠),Liu Jin-ling(刘金陵) *et al.*,1999. Fossil Spores and Pollen of China. Vol 1. Late Cretaceous and Tertiary Spores and Pollen. Beijing: Science Press. 1—910(in Chinese with English summary).

Sternberg C M,1932. Dinosaur tracks from Peace River,British Columbia. National Museum of Canada,Annual Report(1930):59—85.

Wang Da-ning(王大宁),Sun Xiu-yu(孙秀玉),Zhao Ying-niang(赵英娘) *et al.*,1990. Palynoflora from Late Cretaceous to Tertiary in some regions of Qinghai and Xinjiang. *In*:Institute of Geology,Chinese Academy of Geological Sciences(中国地质科学院地质研究所),Geological Brigade of Northwestern Petroleum Geological Bureau,Ministry of Geology and Mineral Resources(地质矿产部西北石油地质局地质大队),Academy of Prospecting and Developing Xinjiang Bureau of Petroleum(新疆石油局勘探开发研究院)(eds.),Study of the Micropaleobotany from the Cretaceous-Tertiary in the Oil-bearing Basins in Some Regions of Qinghai and Xinjiang. Beijing:China Environmental Science Press. 1—179(in Chinese with English summery).

Weems R E,1992. A re-evaluation of the taxonomy of Newark Supergroup saurischian dinosaur tracks,using extensive statistical data from a recently exposed tracksite near Culpeper,Virginia. *In*:Sweet P C(ed.),Proceedings of the 26th Forum on the Geology of Industrial Minerals. Virginia Division of Mineral Resources Publication,**119**:113—127.

Welles S P,1971. Dinosaur footprints from the Kayenta Formation of northern Arizona. Plateau,**44**:27—38.

Xing Li-da(邢立达),Wang Feng-ping(王丰平),Pan Shi-gang(潘世刚) *et al.*,2007. The discovery of dinosaur footprints from the Middle Cretaceous Jiaguan Formation of Qijiang County,Chongqing City. Acta Geologica Sinica(地质学报),**81**(11):1591—1602(in Chinese with English summary).

Xing Li-da,Jerald D Harris,Feng Xiang-yang *et al.*,2009a. Theropod(Dinosauria:Saurischia) tracks from Lower Cretaceous Yixian Formation at Sihetun,Liaoning Province,China and possible track makers. Geological Bulletin of China,**28**(6):705—712.

Xing Li-da,Jerald D Harris,Sun Deng-hai *et al.*,2009b. The earliest known deinonychosaur tracks from the Jurassic-Cretaceous boundary in Hebei,China. Acta Palaeontologica Sinica(古生物学报),**48**(4):662—671.

Xing Li-da,Jerald D Harris,Dong Zhi-ming *et al.*,2009c. Ornithopod(Dinosauria:Ornithischia) tracks from the Upper Cretaceous Zhutian Formation in Nanxiong Basin,China and general observations on large Chinese Ornithopod footprints. Geological Bulletin of China,**28**(7):829—843.

Xing Li-da,Jerald D Harris,Jia Cheng-kai *et al.*,2011. Early Cretaceous bird-dominated and dinosaur footprint assemblages from the northwestern margin of the Junggar Basin,Xinjiang,China. Palaeoworld,(20):308—321.

Xing Li-da,Jerald D Harris,Gerard D Gierliński,2011. *Therangospodus* and *Megalosauripus* track assemblage from the Upper Jurassic-Lower Cretaceous Tuchengzi Formation of Chicheng County,Hebei Province,China and their paleoecological implications. Vertebrata PalAsiatica,**49**(4):423—434.

Young C C,1960. Fossil footprints from China. Vertebrata PalAsiatica,**4**(2):53—66.

Zhen S N,Li J J,Rao C G *et al.*,1989. A review of dinosaur footprints in China. *In*:Gillette D D,Lockley M G(eds.),Dinosaurs:Past and Present. Cambridge:Cambridge University Press. 187—197.

Zhen Suo-nan(甄朔南),Li Jian-jun(李建军),Zhang Bao-kun(张宝堃)*et al.*,1995. Dinosaur and bird footprints from the Lower Cretaceous of Emei County,Sichuan,China. Memoirs of the Beijing Natural History(北京自然博物馆研究报告),**54**:105—120(in Chinese with English summary).

Zhen Suo-nan(甄朔南),Li Jian-jun(李建军),Zhen Bai-ming(甄百鸣),1983. Dinosaur footprints of Yuechi,Sichuan. Memoirs of the Beijing Natural History Museum(北京自然博物馆研究报告),**25**:1—19(in Chinese with English summary).