

THE FIRST DISCOVERY OF DINOSAUR FOOTPRINT FROM LUFENG OF YUNNAN PROVINCE, CHINA

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ABSTRACT

Lufengopus dongi, a new ichnogenus and ichnospecies of theropod dinosaur footprint is erected. The holotype is from the Upper Lufeng Formation of the Middle Jurassic, Lufeng County, Yunnan Province of southern China. *Lufengopus dongi* gen. et sp. nov. is characterized by its large size (the maximum length is approximately 40 cm), and relatively wider width between the second and fourth toes, the ratio of the maximum length to width of the footprint is 1.25. The discovery of the large-sized theropod dinosaur footprint provides a strong evidence for the potential findings of large theropod dinosaur bones in this area, although till now, no theropod dinosaur body fossil corresponding to this footprint size has been found.

Key words: *Lufengopus*, dinosaur footprint, theropod, Lufeng County, Middle Jurassic

INTRODUCTION

Lufeng Basin of Yunnan Province plays an important role in the study of fossil vertebrates, not only in China but also in the world. Since the late 1930s, the diverse fossil vertebrates from the Lufeng Basin have been an important source of information for our understanding of Triassic–Jurassic tetrapod assemblages (Luo and Wu, 1994). The Lower Lufeng Formation yielded lots of tetrapod fossils, and these include the Chinese first dragon *Lufengosaurus*, which was the first skeleton excavated and reconstructed by Chinese paleontologist C. C. Young (Young, 1941a). Not only lots of prosauropod and sauropod dinosaurs were found from the Lower Lufeng Formation (Early Jurassic) and the Upper Lufeng Formation (Middle Jurassic) of Lufeng Basin (Young, 1939, 1941a, b, 1947, 1948, 1951; Bai et al., 1990; Zhang and Yang, 1995), but also early mammals and other fossil vertebrates had been found (Chow and Hu, 1959; Cui, 1976, 1981; Patterson and Olson, 1961; Young, 1940, 1944, 1947, 1951, 1982; Luo and Wu, 1994). Lufeng Basin is an ideal site for the study of the origin and evolution of prosauropod and sauropod dinosaurs and early mammals.

Although abundant prosauropod and sauropod dinosaurs have been found from the Lufeng Basin, no dinosaur footprints have been discovered. The single footprint describe herein was left by a large sized theropod dinosaur, and it provides the strong evidence for the theropod dinosaur's activities at that time and the potential findings of body fossils in the future.

GEOLOGICAL SETTINGS

According to Zhang and Li (1999), the dinosaur footprint bearing deposits belong to the second member of the Upper Lufeng Formation, Middle Jurassic (Fig. 1A, B). The thickness of this member is about 186 m. The dinosaur footprint-bearing layer consists of purple-reddish, medium to thick mudstone, inter-bedded with the yellowish-green, silty mud conglomerate. Well-developed shallow purple-gray mud-cracks are present 10 cm below the dinosaur-bearing layer (Fig. 2). This layer indicates a long period of drought.

SYSTEMATIC PALEONTOLOGY

Theropoda Marsh, 1881

Ichnofamily EUBRONTIDAE Lull, 1904

LUFENGOPUS ichnogen. nov.

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FIGURE 1A. Map showing the fossil locality. ★ stands for fossil site.



FIGURE 1B. The outcrop of the fossil locality (arrow points to the footprint).

Etymology.— “Lufeng” referring to the fossil locality, Lufeng County of Yunnan Province; “pus” referring to foot.

Diagnosis.— as for the only species.

Ichnospecies *LUFENGOPUS DONGI* ichnosp. nov.
(Fig. 3A–B)

Etymology.— The species is named in honor of the famous dinosaur expert, Professor Zhiming Dong of Institute of Vertebrate Paleontology and Paleoanthropology, who made great contributions to the study and protection of Lufeng dinosaurs.

Holotype.— A complete natural mould of the left footprint. The specimen is housed at the Lufeng Dinosaur Museum, No. L 028. The cast of the specimen is stored in Heyuan Museum, Guangdong Province (HYMVC-1).

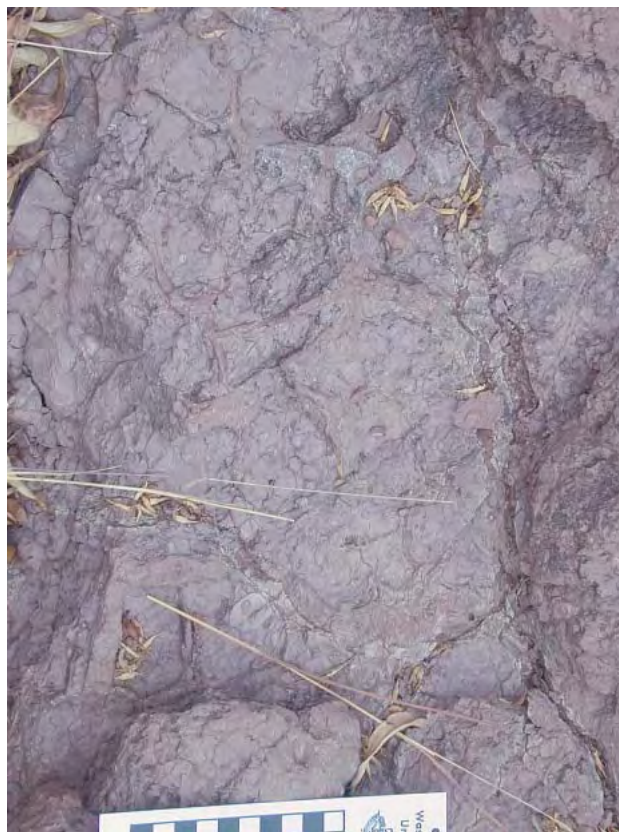


FIGURE 2. The mud-crack structures 10 cm below the dinosaur foot-bearing layer.

Type locality and horizon.— The footprint is found at the Beikeshan (Shelled hill) near Yaozhan, 1 km southeast to Chuanjie (N24° 7' 49.4" ; E102° 4' 41.4"), Lufeng County (Fig. 1 A), the second member of the Upper Lufeng Formation, Middle Jurassic (Zhang and Li, 1999).

Diagnosis.— A large sized bipedal dinosaur footprint with separated phalangeal pads, and the pad formula is 2-3-3 indicating that this animal bears a short metatarsal IV. Distinctive circular heel pad impression is present. Each digital impression tapers distally to a point, corresponding to a sharp claw. The maximum length is approximately 40 cm; the ratio of the maximum length to width is 1.14; the divergence of the second and third toe is 29°; the divergence of the third and fourth toe is 35°.

DESCRIPTION

Only one dinosaur footprint is exposed and well-preserved in the field, although other footprints may still be buried in the same layer of the sedimentary rocks. More footprints or trackways may be discovered after removing the overlying deposits of the footprint-bearing layer. The outline of the footprint shows that it is relatively wide and short (Fig. 3A). The

TABLE 1. Measurements of *Lufengopus dongi* gen. et sp. nov. (L028) (in cm)

Elements	Data
Maximum length	40
Maximum width (distance between the tips of the second and fourth toes)	35
Length of the second toe	23.5
Length of the third toe	24
Length of the fourth toe	24
Angle between the second and third toes	29°
Angle between the third and fourth toes	35°
Angle between the second and fourth toes	64°

separated phalangeal pads and distinctive circular heel pad impression can be clearly observed. The pes impressions indicate a functionally tridactyl foot, with the inner digit II smaller than others. Digit III is as long as digit IV. The distinctive, deep groove-like claw marks are observed at the tip of the toes, especially, at the tip of the second toe, indicating sharp claws rather than rounded hooves. The maximum length of the footprint is approximately 40 cm, and its maximum width (distance between the tips of the second and fourth toes) is 35 cm. The ratio of the maximum length to maximum width of the footprint is 1.14. The divergence of the third and fourth toe is 35°, which is greater than that of the second and third toe, which is 29°. The measurements of *Lufengopus dongi* gen. et sp. nov. are listed in Table 1.

According to Lull (1904), in the tridactyl or tetradactyl dinosaur tracks, the claw of the digits II and IV point away from the axis of the foot while the claw of the digit III is invariably bent inward toward the middle of the trackway. The claw of *Lufengopus* bent to the right, thus, this footprint was left by the left foot of a theropod dinosaur (Fig. 3).

COMPARISON AND DISCUSSION

Lufengopus is largest among the theropod dinosaur footprints found from China, such as *Grallator* (the bottom of the Fengjiahe Formation of the Early Jurassic; Zhen et al., 1986), *Jeholosauripus* (Early Jurassic, Chaoyang of Liaoning Province; Yabe et al., 1940), *Schizograllator* and *Paracoelurosaurichus* (the bottom of the Fengjiahe Formation, Early Jurassic; Zhen et al., 1986), *Zizhongpus* (the bottom of the Xintiangou Formation of the Middle Jurassic; Yang and Yang, 1987), *Chongqingpus* (the middle part of the Lower Shaximiao Formation of the Middle Jurassic, Yang and Yang, 1987), *Velociraptorichnus* (Jiaguan Formation of the Early Cretaceous; Zhen et al., 1995), *Laiyangpus* (Laiyang Formation, Late Jurassic; Young, 1960), *Shensipus* (Early to Middle Jurassic; Young, 1966), *Changpeipus carbonicus* (Early–Middle Jurassic; Young,

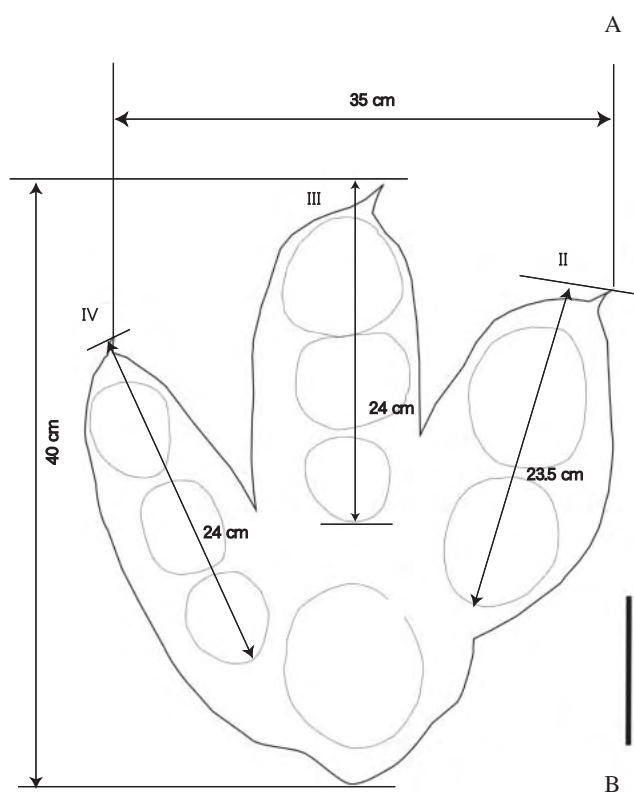


FIGURE 3. Photograph (A) and the line drawings (B) of the holotype *Lufengopus dongi* ichnogen. et ichnosp. nov. (L028), scale bar = 10 cm.

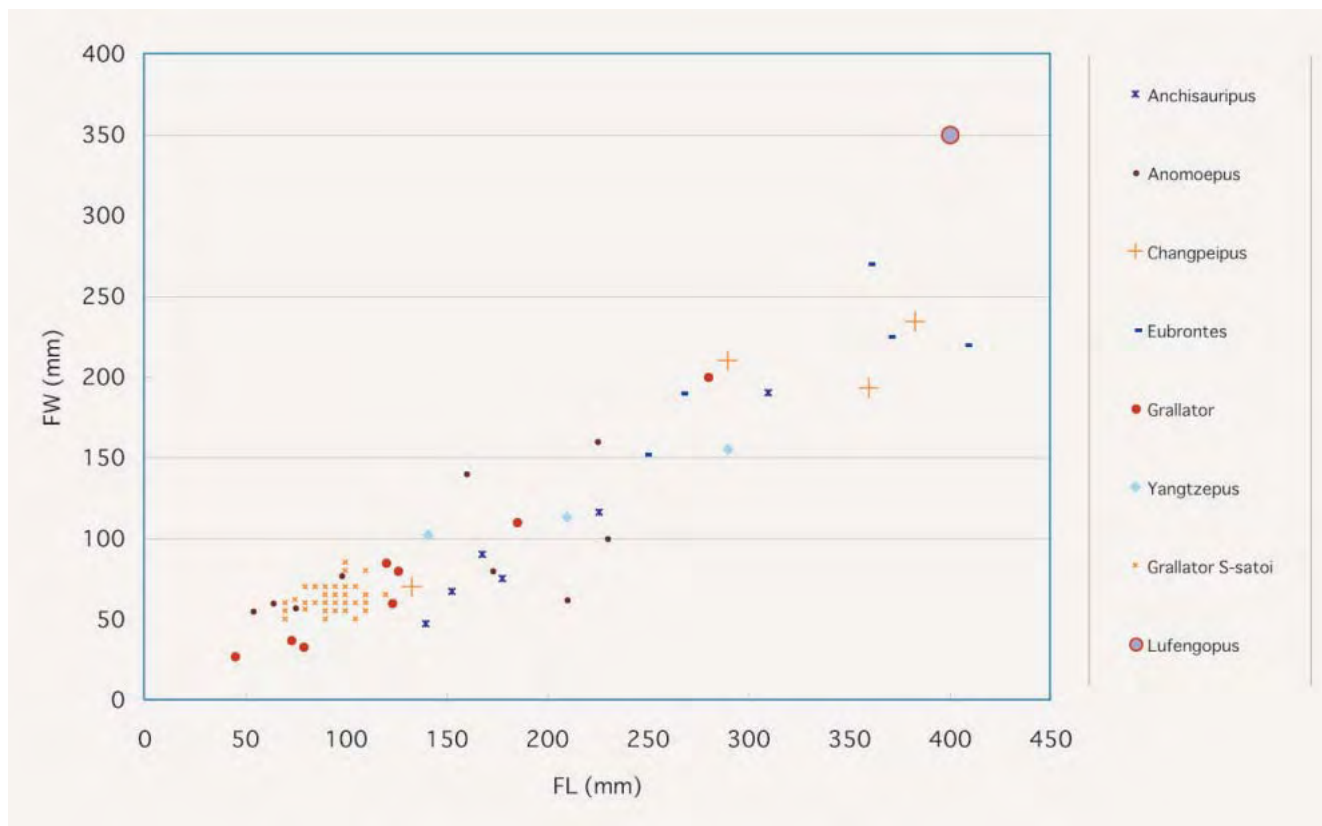


FIGURE 4. The scatter diagram of width to length of the theropod dinosaur footprints.

1960), *Changpeipus luanpingensis* (Late Jurassic, Luanping of Hebei Province; Young, 1979). Almost all of the above-mentioned theropod footprints are narrower and smaller. The scatter diagram of the relationship between foot length and foot width shows that *Lufengopus* is closer to *Eubrontes* and *Changpeipus* than to other theropod footprints (Fig. 4). There is a big gap between the group formed by both *Eubrontes* and *Changpeipus* and *Lufengopus* in Figure 4, therefore, it clearly shows that *Lufengopus* represents a new kind of theropod dinosaur footprint found so far in China.

Although metatarso-phalangeal pads are blur in the field, the cast of the footprint displays a clear metatarso-phalangeal pads (Fig. 3B). The typical theropod footprints reveal a digital pad formula of 2-3-4, corresponding to digits II, III and IV (Lockley and Meyer, 2000). *Lufengopus dongi* indicates the pad formula of 2-3-3 and implies that this animal bears a short metatarsal IV, as in the case of *Carmelopodus*, a small theropod track found from the Middle Jurassic of Buckinghamshire and eastern Utah (Lockley and Meyer, 2000). The discovery of *Lufengopus* provides the strong evidence for the potential findings of body fossils in the future.

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REFERENCES

- Bai, Z. Q., J. Yang and G. Wang. 1990. *Yimenosaurus* a new genus of Prosauropoda from Yixmen County, Yunnan Province. *Yuxiwenbo* (Yuxi Culture and Scholarship) 1: 14–23.*
- Chow, M. Z., and C. C. Hu. 1959. A new tritylodontid from Lufeng, Yunnan. *Vertebrata Palasiatica* 3: 9–12.*
- Cui, G. H. 1976. *Yunnanania*, a new tritylodontid from Lufeng, Yunnan. *Vertebrata Palasiatica* 14(2): 85–90.*

- Cui, G. H. 1981. A new genus of tritylodontidae. *Vertebrata Palasiatica* 19 : 5–10.*
- Lockley, M., and C. Meyer. 2000. The dark ages : Middle Jurassic ; pp. 133–149 in M. Lockley and C. Meyer (eds.), *Dinosaur tracks and other fossil footprints of Europe*. Columbia University Press, New York.
- Lull, R. S. 1904. Fossil footprints of the Jura-Trias of North America. *Memoirs read before the Boston Society of Natural History* 5 : 461–557.
- Luo, Z., and X. Wu. 1994. The small tetrapods of the Lower Lufeng Formation, Yunnan, China ; pp. 251–270 in N. C. Fraser and H-D Sues (eds.), *The Shadow of the Dinosaurs*. Cambridge University Press, New York.
- Marsh, O. C. 1881. Principal characters of American Jurassic dinosaurs. Part 5. *American Journal of Sciences (Ser. 3)* 21 : 417–423.
- Patterson, B., and E. C. Olson. 1961. A triconodontid mammal from the Triassic of Yunnan ; pp. 129–191 in *International Colloquium in the Evolution of Lower and Nonspecialized Mammals*. Brussels : Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van Belgie.
- Yabe, H., Y. Inai and T. Shikama. 1940. Discovery of Dinosaurian Footprints from the Cretaceous (?) of Yangshan, Chinchou. *Preliminary Note. Proceedings of Imperial Academy of Tokyo* 15 : 560–563.
- Yang, X. L., and D. H. Yang. 1987. *Dinosaur footprints from the Sichuan Basin*. Sichuan Publishing House of Science and Technology, Chengdu, 30 pp.*
- Young, C. C. 1939. Preliminary observation of *Lufengosaurus*. *Geological Review* 4 : 91–96.
- Young, C. C. 1940. Preliminary note on the Mesozoic mammals of Lufeng, Yunnan, China. *Bulletin of the Geological Society of China* 20 : 93–111.
- Young, C. C. 1941a. A complete osteology of *Lufengosaurus huenei* (gen. et sp. nov.) from Lufeng Yunnan, China. *Paleontologia Sinica (New Series C)* 7 : 1–53.
- Young, C. C. 1941b. *Gyposaurus sinensis* sp. nov., a new Prosauropoda from the Upper Triassic Beds at Lufeng, Yunnan. *Bulletin of the Geological Society of China* 21 : 205–252.
- Young, C. C. 1944. On a supposed new pseudosuchian from the Upper Triassic saurischian-bearing beds of Lufeng, Yunnan, China. *American Museum Novitates* 1264 : 1–4.
- Young, C. C. 1947. On *Lufengosaurus magnus* (sp. nov.) and additional finds of *Lufengosaurus huenei* Young. *Paleontologia Sinica* 132 (New Series C) 12 : 1–53.
- Young, C. C. 1948. Further notes on *Gyposaurus sinensis* Young. *Bulletin of the Geological Society of China* 28 : 91–103.
- Young, C. C. 1951. The Lufeng Saurischian Fauna in China. *Paleontologia Sinica (New series C)* 13 : 1–94.
- Young, C. C. 1960. Fossil footprints in China. *Vertebrata Palasiatica* 4 : 53–66.
- Young, C. C. 1966. Two footprints from the Jiaoping coal mine of Tungchuan, Shensi. *Vertebrata Palasiatica* 10 : 68–71.
- Young, C. C. 1979. Footprints from Luanping, Hebei. *Vertebrata Palasiatica* 17 : 116–117.
- Young, C. C. 1982. On a new genus of dinosaur from Lufeng, Yunnan ; pp. 38–42 : in *Selected Works of Yang Zhong-jian*. Science Press, Beijing.
- Zhang, Y. H., and Z. L. Yang. 1995. A new complete osteology of prosauropoda in Lufeng Basin, Yunnan China : *Jingshanosaurus*. Yunnan Publishing House of Science and Technology, Kunming, China, 99pp.**
- Zhang, Z. X., and X. K. Li. 1999. A study on the stratigraphic section bearing the new sauropoda fauna in Laochangjing, Lufeng. *Yunnan Geology* 18(1) : 72–82.*
- Zhen, S. N., J. J. Li, C. G. Rao and S. J. Hu. 1986. Dinosaur footprints of Jinning, Yunnan. *Memoirs of the Beijing Natural History Museum* 33 : 1–17.**
- Zhen, S. N., J. J. Li, B. K. Zhang, W. Chen and S. L. Zhu. 1995. Dinosaur and bird footprints from the Lower Cretaceous of Emei County, Sichuan, China. *Memoirs of Beijing Natural History Museum* 54 : 105–120.**

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