

RAPID COMMUNICATION

An Early Cretaceous spinosaurid theropod from southern China

ERIC BUFFETAUT*†, VARAVUDH SUTEETHORN‡, HAIYAN TONG* & ROMAIN AMIOT§

*Centre National de la Recherche Scientifique (UMR 8538), Laboratoire de Géologie de l'École Normale Supérieure,
24 rue Lhomond, 75231 Paris Cedex 05, France

‡Bureau of Fossil Research and Museum, Department of Mineral Resources, Rama VI Road, Bangkok 10400, Thailand

§Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 XiZhiMenWai DaJie,
Beijing 100044, China

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Abstract

Teeth from the Early Cretaceous Napai Formation of Fusui County, Guangxi Zhuang Autonomous Region (South China), initially described as the sauropterygian *Sinopliosaurus fusuiensis*, are redescribed as belonging to a spinosaurid theropod closely allied to *Siamosaurus suteethorni*, from the Early Cretaceous of Thailand. This identification extends to China the geographical range of Asian spinosaurs, previously reported from Thailand and Japan.

Keywords: Cretaceous China Plesiosauria Dinosauria Theropoda Spinosauridae

1. Introduction

In 1975, Hou, Yeh & Zhao described a small vertebrate assemblage from the Early Cretaceous Napai Formation (erroneously transliterated as 'Napan' by Dong, 1992) in Fusui County, Guangxi Zhuang Autonomous Region (southern China). In 1995, during a visit to the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) in Beijing, one of us (VS) examined the reptile remains from Fusui and noticed that the teeth referred to a pliosaur (as *Sinopliosaurus fusuiensis*) in fact showed similarities with teeth from the Early Cretaceous of Thailand described as *Siamosaurus suteethorni* Buffetaut & Ingavat, 1986, and tentatively referred to a spinosaurid theropod (Buffetaut & Ingavat, 1986). Re-examination of the material from Fusui, together with new discoveries of spinosaurid theropods from Thailand, allows us to reinterpret the supposed pliosaur from the Napai Formation as a spinosaur.

2. Geographical and geological setting

Fusui County is in the southeastern part of Guangxi Zhuang Autonomous Region, about 45 km to the SW of the regional capital, Nanning. A detailed map of the locality was provided by Hou, Yeh & Zhao (1975), together with a stratigraphic section of the Napai Formation, which they attributed to the Early Cretaceous period on the basis of bivalves (notably *Trigonioides*). Vertebrate remains, from purple marls intercalated with sandstones, were listed as consisting of a hybodont shark tooth, fragmentary plates of a cryptodiran turtle, five teeth of a pliosaurid (*Sinopliosaurus fusuiensis*), a

spatulate tooth, three incomplete cervical vertebrae and ribs of a brachiosaurid sauropod (*Asiatosaurus kwangshiensis*) and four teeth of a megalosaurid theropod (*Prodeinodon kwangshiensis*). The validity of the dinosaur taxa established on the basis of this very fragmentary material is questionable. According to Dong (1992), the sauropod material can be referred to a euhelopodid. Buffetaut, Suteethorn & Tong (2006) compared the vertebrate assemblage from Fusui with more diverse Early Cretaceous assemblages from northeastern Thailand and concluded that the Napai Formation may be correlated with either the Sao Khua Formation (Hauterivian–Barremian?) or the Khok Kruat Formation (Aptian). Dong (1979a) reported the occurrence of ornithopod bones in the Napai Formation, a faunal similarity it shares with the Khok Kruat Formation, which has yielded remains of early hadrosauroids.

3. A redescription of the teeth referred to *Sinopliosaurus fusuiensis*

Hou, Yeh & Zhao (1975) mentioned five teeth referable to *Sinopliosaurus fusuiensis*, but only four could be found in the IVPP collection. Three of them are poorly preserved and the description below is based on the most complete specimen (IVPP V 4793), which has undergone some deformation and lacks the most apical part of the tip (Fig. 1). The crown is tall, slender, and recurved. As noted by Hou, Yeh & Zhao (1975), it is compressed laterally (i.e. labiolingually) rather than circular in cross-section (as shown erroneously in their fig. 3). Distinct carinae are present mesially and distally, extending from the base of the crown to its apex; these carinae, not shown clearly on the figure published by Hou, Yeh & Zhao (1975, fig. 3) but mentioned in their description, are in the plane of curvature of the tooth, so that the mesial carina is convex and the distal carina concave. The enamel bears an ornamentation of well-marked apicobasal ridges, of which there are approximately twelve on each face. These ridges are somewhat irregular, and not all extend for the whole length of the crown. In addition to the ridges, the enamel shows a finer ornamentation of sinuous wrinkles that are developed between the ridges and are particularly marked near the apex (Fig. 1d). The wrinkles extend over the carinae, where they form ill-defined serrations, but these are completely obliterated by wear along most of the length of the carinae. The apicobasal height of the crown is 69 mm, and its greatest and smallest diameters at its base are, respectively, 16.5 mm and 13 mm.

†Author for correspondence: eric.buffetaut@wanadoo.fr

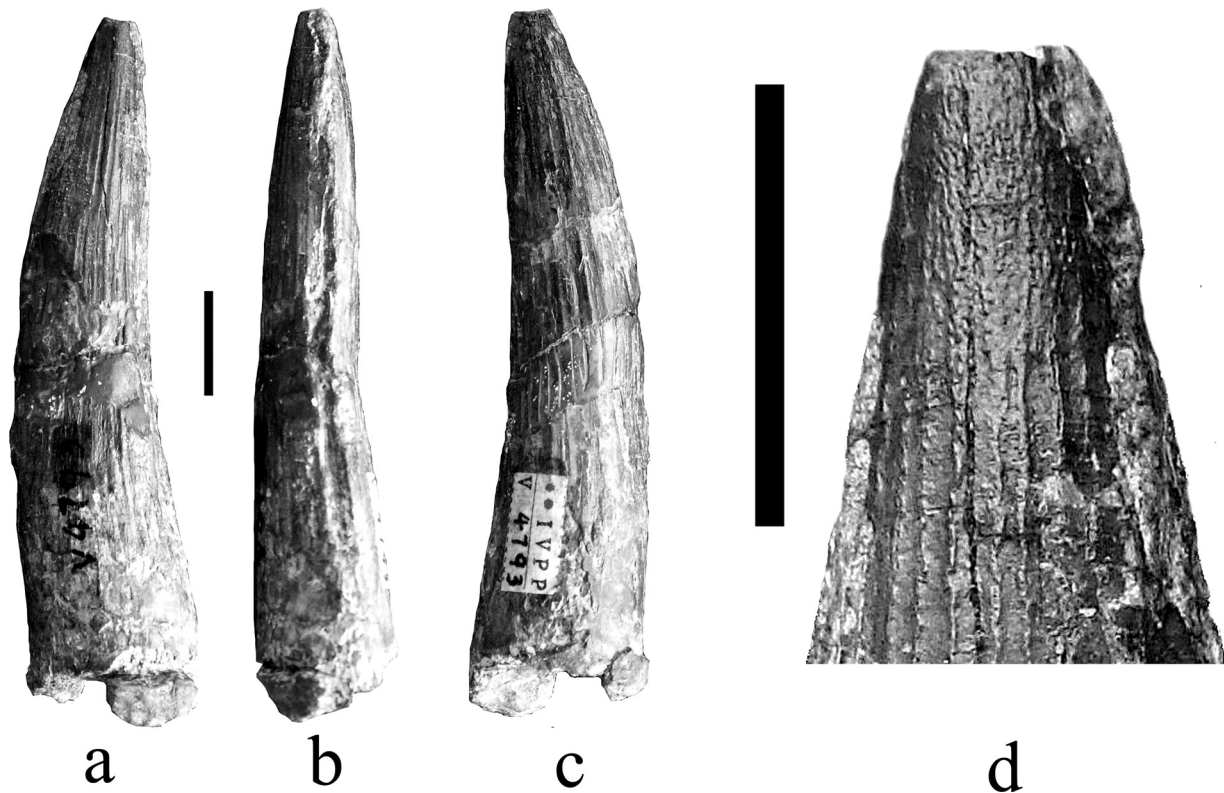


Figure 1. Spinosaurid tooth from the Napai Formation (Early Cretaceous) of Fusui county, Guangxi Zhuang Autonomous Region, southern China, IVPP V 4793, in lingual (a), distal (b) and labial (c) views, and close up of apex in lingual view (d), showing ribs and enamel wrinkling. Scale bars: 10 mm.

4. Comparisons and identification

Hou, Yeh & Zhao (1975) identified the above-mentioned teeth as belonging to the genus *Sinopliosaurus* Young, which has a complex nomenclatural history. Young first mentioned the genus in 1942, when he referred three teeth from the Jurassic of Kuangyuan, Sichuan Province, to the species *Sinopliosaurus weiyuanensis*, because 'they agree perfectly with the tooth previously described from Weiyuan' (Young, 1942, p. 306). In fact, as Young himself mentioned in a footnote, his paper on the Jurassic fossils from Weiyuan (Sichuan Province), in which he formally erected the species *Sinopliosaurus weiyuanensis*, was still in press when the description of the teeth from Kuangyuan appeared, and was not published until 1944 (Young, 1944). On the basis of publication dates, *Sinopliosaurus weiyuanensis* Young, 1942 thus should have priority over *Sinopliosaurus weiyuanensis* Young, 1944. The material from Weiyuan referred by Young (1944) to a pliosaur includes a tooth, vertebrae, an ischium and a femur. What has been overlooked by many authors, however, is that in 1948 Young changed his mind about the specimens from Kuangyuan and Weiyuan. He considered that the teeth more probably belonged to the crocodylian *Peipehsuchus teleorhinus* and that the vertebrae also probably belonged to a crocodylian (which does seem likely), so that only the ischium and the femur clearly belonged to a pliosaur; he expressly designated the femur as the type of *Sinopliosaurus weiyuanensis* (Young, 1948). Curiously enough, Dong (1979b) and Sun *et al.* (1992) figured as belonging to *Sinopliosaurus weiyuanensis* a tooth from Kunghsien, in southern Sichuan, originally described by Young (1935) as pliosaurian, but later referred by him to the crocodylian *Peipehsuchus teleorhinus*, together with the teeth

from Kuangyuan and Weiyuan (Young, 1948). Hou, Yeh & Zhao (1975) compared the specimens from Fusui with the teeth from Weiyuan and with poorly preserved teeth from the Early Cretaceous of Wuerho, Xinjiang, described by Young (1973) as possibly belonging to *Sinopliosaurus weiyuanensis* or to another taxon of pliosaur. They considered the teeth from Fusui as belonging to a distinct species on the basis of small differences in ornamentation and compression of the crown.

The specimens described by Young have been considered as non-diagnostic by various authors (Tarlo, 1960; Sato, Li & Wu, 2003). In view of the extremely fragmentary nature of the material, *Sinopliosaurus weiyuanensis* should certainly be considered as a *nomen dubium*. Moreover, the teeth originally referred to that taxon were later attributed by Young (1948) to crocodylians; they are at best of dubious affinities and do not show distinctive pliosaur characters, so that purported similarities between them and the teeth from Fusui actually cannot be used to refer the latter to a pliosaur. The Cretaceous teeth from Wuerho described by Young (1973) may belong to pliosaurus but show few similarities with the Fusui material.

Plesiosaur (including pliosaur) remains do occur in Jurassic and Cretaceous non-marine sediments in various parts of the world, including China (see Sato, Li & Wu, 2003, for a recent review), and there would be nothing unusual about the presence of a freshwater pliosaur in the Napai Formation. However, while *Sinopliosaurus weiyuanensis* was partly based on plesiosaur material (the femur and ischium), *Sinopliosaurus fusuiensis* in our opinion is not. The teeth from Fusui differ from those of pliosaurus in several respects. In particular, carinae in the plane of curvature of the tooth do not occur in plesiosaurus and pliosaurus (see e.g. Owen, 1851; Andrews, 1913; Bigot, 1938; Tarlo, 1960); the teeth of pliosaurus have a concave lingual face and a convex labial

face, whereas in the teeth from Fusui the crown is convex mesially and concave distally. In that respect, they also differ from those of all crocodylians, except the ziphodont forms (in which, however, the enamel is usually smooth), but are similar to the teeth of theropod dinosaurs. The ornamentation of the enamel is also different: in pliosaurs the ribs are finer and often do not extend over the whole length of the crown, and frequently the labial face of the crown is smooth or bears only a few ribs.

Although the teeth from Fusui differ from 'normal' theropod teeth in their limited labiolingual compression, in the strong ornamentation of their enamel and in the lack of very distinct serrations on the carinae, they closely resemble the teeth of some spinosaurid theropods. The curvature of the crown, the position of the carinae and the wrinkling of the enamel are similar to the condition in *Baryonyx walkeri* from the Wealden of England (Charig & Milner, 1997) – in which, however, serrations are much better defined. The ribs on the surface of the enamel are more strongly marked on the Fusui teeth than in the holotype of *Baryonyx walkeri*, but in some *Baryonyx*-like teeth from the Early Cretaceous of England and Portugal fairly strong ribbing occurs (Buffetaut, 2007). The closest resemblance is with teeth from the Early Cretaceous Sao Khua Formation of Thailand described as *Siamosaurus suteethorni* by Buffetaut & Ingavat (1986), which show the same shape of the crown and the same ribbing and wrinkling of the enamel, together with very poorly defined serrations; a tooth from the Early Cretaceous Sebayashi Formation of Japan shows very similar characters (Hasegawa *et al.* 2003). In view of these similarities, we suggest that the teeth from the Napai Formation at Fusui described as *Sinopliosaurus fusuiensis* belong to an animal closely related to, if not identical with, *Siamosaurus suteethorni*.

Buffetaut & Ingavat (1986) tentatively referred *Siamosaurus suteethorni* to the Spinosauridae. Although this interpretation met with some scepticism, it is becoming clear that some European 'baryonychines' had a strongly ornamented dental enamel that does not differ much from that of *Siamosaurus*. Moreover, an incomplete skeleton recently found in the Early Cretaceous Khok Kruat Formation of Thailand, where *Siamosaurus*-type teeth occur, clearly belongs to a spinosaurid theropod (Buffetaut *et al.* 2005; Milner, Buffetaut & Suteethorn, 2007). No teeth have been found in association with that specimen, so that it cannot yet be fully demonstrated that the *Siamosaurus* teeth and the spinosaur skeleton from the Khok Kruat Formation belong to the same form. Nevertheless, there are now several converging lines of evidence to indicate that *Siamosaurus* is indeed a spinosaurid theropod, as originally suggested. We therefore refer the teeth from the Napai Formation originally described as *Sinopliosaurus fusuiensis* to a spinosaurid theropod closely similar to *Siamosaurus*. Interestingly, this is not the first instance of spinosaurid teeth being misidentified as those of aquatic reptiles. Kobayashi, Takai & Hayami (1964) identified as ichthyosaurian a tooth from the Khorat Group of Thailand (Sao Khua Formation: Ward & Bunnag, 1964) that apparently belongs to *Siamosaurus*, while Schlüter & Schwarzhan (1978) described *Spinosaurus* teeth from the Albian of Tunisia as belonging to *Plesiosaurus* sp.

5. Conclusions

The identification of the 'pliosaur' teeth from Fusui as those of a spinosaurid extends to China the known distribution of spinosaurs in Asia. As mentioned above, they had previously been reported from the Early Cretaceous of Thailand (from

localities that were probably close to southern China in the Early Cretaceous, before the 'extrusion' of SE Asia following the collision of the Indian plate with Asia in the Tertiary) and Japan. Nessov (1995) described teeth from the Santonian–Campanian of Uzbekistan as *Asiamericana asiatica* and considered that they belonged either to a spinosaurid theropod or to a saurodontid fish. The latter interpretation is certainly correct, as later noted by Nessov (1997).

Spinosaurids were first reported from Africa (Stromer, 1915), and then from Europe and South America (see review in Buffetaut & Ouaja, 2002). Conflicting hypotheses of vicariant evolution versus dispersal across the Tethys must now be re-evaluated in view of the presence of the group in Asia at a time when it was also present in Africa, Europe and South America.

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