

THAI DINOSAURS; AN UPDATED REVIEW

Varavudh Suteethorn¹, Yaowalak Chaimanee¹, Somchai Triamwichanon¹, Chanwichai Suksawat¹, Sasithorn Kamsupha¹, Amphorn Kumchoo¹, Eric Buffetaut², Valerie Martin³ and Haiyan Tong²

1. Geological survey division, DMR.

2. Centre National de la Recherche Scientifique, Laboratoire de Paleontologie des Vertebres, Universite Paris 6, Case 106, 4 place Jussieu, 75252 Paris Cedex 05, France;

3. Musee des Dinosaurues, 11260 Esperaza, France

Dinosaur remains were first found in Thailand in the 1970s, and systematic prospections and excavations were started in the 1980s. Since then, a large amount of material has been discovered by our Thai-French group, and the dinosaur record from Thailand is by far the best in South-East Asia. Although several review papers have been published in recent years (Buffetaut and Suteethorn, 1993; Martin et al., 1993), a number of new finds and interpretations have enlarged and modified our knowledge of Thai dinosaurs since their publication. The aim of the paper is to present a concise updated review of that is known about the dinosaurs of Thailand.

Geological setting

All the dinosaur remains hitherto found in Thailand come from the non-marine Mesozoic rocks of the Khorat Plateau of northeastern Thailand. They were found in several formations belonging to what is traditionally known as the Khorat Group, a thick succession of sediments which was long thought to range in age from Later Triassic to Cretaceous. However, correlating the formations of the Khorat Group with the standard chronostratigraphic scale has proved difficult, because of the lack of marine intercalations. Recently, a major reinterpretation of the ages of many of the formations of the Khorat Plateau has been proposed on the basis of palynological and fission track studies (Racey et al., 1994; Bristow et al., 1994). These studies

suggest that the Phra Wihan Formation and the overlying Sao Khua Formation, long thought to be, respectively, Middle and Late Jurassic in age, should in fact be placed in the Early Cretaceous, together with the overlying Phu Phan and Khok Kruat Formations. The age of the underlying Phu Kradung Formation remains uncertain, but it seems to be younger than the previously accepted Early Jurassic age, although a Jurassic age still seems likely. The Nam Phong Formation, formerly placed at the base of the Khorat Group, is dated as Late Triassic on the basis of palynology, and now seems to be separated from the overlying formations by a considerable hiatus, so that it should probably be excluded from the Khorat Group. The succession of Mesozoic nonmarine formations on the Khorat Plateau is now thought to be much more discontinuous than was previous thought. This has important consequences for the dating of some of the dinosaur-bearing formations of the Khorat Plateau, in particular the especially productive Sao Khua Formation.

The oldest Thai dinosaur :A prosauropod from the Nam Phong Formation

The Nam Phong Formation, which is very probably Late Triassic in age (Late Norian to Rhaetian according to Racey et al., 1994, on the basis of palynological evidence), was long thought to be devoid of vertebrate fossils. Recently, however,

fragmentary dinosaur bones were found in the Nam Phong Formation near the eastern entrance to Nam Nao National Park, west of the city of Chum Phae, by Nares Sattayarak (Department of Mineral Resources, Bangkok). Further researches at the site by one of us (V.S.) resulted in the recovery of the fused distal ends of the ischia of a fairly large and robust prosauropod dinosaur, which is in agreement with the age suggested by palynological evidence. The specimen is currently under study. It is too incomplete to allow a very precise identification, but its discovery shows that prosauropods were present in the South East Asia in the Late Triassic and will encourage further prospection in the Nam Phong Formation.

The dinosaur footprints from the Phra Wihan Formation

Although the Phu Kradung formation, which overlies the Nam Phong Formation, and is probably Jurassic in age, has yielded various remains of fishes, temnospondyl amphibians (Buffetaut et al., 1994), turtles and crocodylians, no dinosaur remains have so far been found in it. In the sandstones of the overlying Phra Wihan Formation, which is referred to the Berasian-Berremian interval by Racey et al. (1994) on the basis of palynology, dinosaur footprints have been found at a site known as Hin Lat Pa Chad, in the Phu Wiang hills of Khon Kaen Province. There is little to add to the preliminary report given by Buffetaut and Suteethorn (1993): ten distinct trackways, trending in more or less parallel directions, have been found on a ripple-marked sandstone surface. Most of the pes prints are under 10 cm. in length, indicating small animals, less than 50 cm tall at the hip. Some of the footprints show three long, slender and pointed toes, and are referable to small theropods. Others exhibit broader toes, and occasionally show small manus prints lateral to the pes impressions. These may have been left by small ornithischians, although theropods cannot be totally excluded. Preliminary

speed estimates suggest slow locomotion. A group of theropod footprints has been reported by Polahan and Daorerk (1993) from Khao Yai National Park (Pra Chin Buri Province). The footprints are on the surface of a loose block of sandstone, and although it clearly comes from the Khorat Group.

The dinosaurs from the Sao Khua Formation

The first dinosaur bones ever found in Thailand came from the Sao Khua Formation, and this formation has since proved remarkably productive, with a number of localities in several provinces (notably Khon Kaen and Kalasin) of the Khorat Plateau. The Sao Khua Formation was long considered as Late Jurassic in age, but the above-mentioned palynological results obtained by Racey et al. (1994) from the underlying Phra Wihan Formation imply that it must be younger, Early Cretaceous, in age.

The most abundant dinosaurs in the Sao Khua Formation are sauropods. An incomplete partly articulated skeleton was found at Phu Pratu Teema, in the Phu Wiang area (Buffetaut and Suteethorn, 1989), and has been chosen as the type of a new taxon, *Phuwiangosaurus sirindhornae*, by Martin, Buffetaut and Suteethorn (1994). Remains of this middle sized sauropod, which apparently could reach a length of 15 to 20 meters, have been found at several other sites in the Sao Khua Formation, notably in the Phu Wiang hills and at Phu Pha Ngo in Kalasin Province. *Phuwiangosaurus sirindhornae* clearly differ from the various sauropods described from the Jurassic of China (such as *Omeisaurus*, *Mamenchisaurus*, *Euhelopus*, etc., which can be placed in the family Euhelopodidae). In particular, its cervical vertebrae are dorsoventrally flattened, whereas compression is transversal in the cervicals of the Chinese genera. In addition, the neural spines of the posterior cervical vertebrae of *Phuwiangosaurus sirindhornae* are deeply bifurcated, whereas the

bifurcation, when present, is very shallow in the Chinese genera. Despite some resemblances in the shape of the cervical vertebrae and the femur, *Phuwiangosaurus* does not seem to be closely related to the *Camarasauridae* because of many differences in the dorsal vertebrae and the girdles. The complex structure of its vertebrae separates it clearly from the primitive sauropods of the families *Vulcanodontidae* and *Cetiosauridae*, and there are no convincing common derived characters that would justify an attribution to the *Diplodocidae*, *Titanosauridae*, *Brachiosauridae* or *Dicraeosauridae*. Although no formal name has yet been proposed, it seems likely that *Phuwiangosaurus* belongs to a family of its own. More data concerning the anatomy and systematic position of *Phuwiangosaurus* may be forthcoming following the discovery in 1994 of a very rich locality at Wak Sak Kawan in Kalasin Province. At the time of writing, excavations are still in progress there. They have already yielded more than one hundred sauropod bones, belonging to at least two individuals. This material includes elements not yet known in *Phuwiangosaurus*, such as the sacrum and parts of the upper jaw containing long slender teeth which are quite different from the broader, more spoon-shaped teeth of *Mamenchisaurus* (as described by Russell and Zheng, 1993). Whether this newly discovered material can be referred to *Phuwiangosaurus sirindhornae* can only be decided once the specimens have been more completely prepared and studied.

Interestingly, many small sauropod bones clearly belonging to juveniles (to judge, for instance, from the lack of fusion of the neural arches with the centra) have been found at several localities in the Phu Wiang area. This postcranial material is attributed to very young individuals of *Phuwiangosaurus sirindhornae* because of morphological resemblances with adult remains from the Sao Khua Formation. The smallest individual seems to have been

less than two metres long and about fifty centimetres tall. Although disarticulated, this material is important because evidence about baby sauropods is scanty. Besides the abovementioned resemblances with adults of *Phuwiangosaurus sirindhornae*, the juvenile bones from Phu Wiang also show interesting features reminiscent of primitive sauropods (such as *Vulcanodon* or *Barapasaurus*), such as the presence of a lesser trochanter on the femur and the simple shape of the centra and pleurocoels.

Theropod dinosaurs are represented in the Sao Khua Formation by various forms. Peculiar teeth with hardly compressed, striated and unserrated crowns have been referred to a possible spinosaurid, *Siamosaurus suteethorni*, by Buffetaut and Ingavat (1986). They are frequent at many sites in the Sao Khua Formation. More usual, compressed and serrated teeth are also frequently encountered (some of them were found among the bones of the type of *Phuwiangosaurus sirindhornae*; see Buffetaut and Suteethorn, 1989). A partly articulated incomplete skeleton of a large theropod, including dorsal and caudal vertebrae, the sacrum and a large part of the pelvis, has recently been found at Phu Wiang and is currently being prepared.

A few bones found at Phu Wiang have been referred to a very small theropod, possibly similar to *Compsognathus* (Buffetaut and Ingavat, 1984). Recently, one of the Phu Wiang localities has yielded a number of postcranial bones (vertebrae, tibiae, metatarsals, phalanges) of a small ornithomimosaur. This animal is more advanced than the primitive ornithomimosaur *Harpymimus* (Aptian-Albian of Mongolia) and *Garudimimus* (Cenomanian-Turonian of Mongolia) in the greater proximal reduction of its third metatarsal, a feature in which it seems to be close to the condition in advanced ornithomimosaur such as *Struthiomimus* or *Gallimimus*. However, its metatarsus is shorter relative to the length of the tibia

than in these advanced forms, and it certainly represents a new taxon indicating the occurrence of fairly advanced ornithomimosaur in the Early Cretaceous.

Vary few remains referable to ornithischians have so far been found in the Sao Khua Formation. A group of caudal vertebrae from Phu Wiang may belong to an iguanodontid-like form.

The dinosaurs from the Sao Khua Formation constitute the most diverse assemblage hitherto found in South East Asia. It shows several interesting features, among which the dominance of sauropods, which contradicts the still widely held idea that sauropods suffered a drastic decline after the end of the Jurassic.

The footprints from the Phu Phan Formation

The Phu Phan Formation, which overlies the Sao Khua Formation, contains very few fossils. Fragments of large bones have been found in it, but they are much too incomplete to be identified. The only important dinosaur fossils hitherto reported from the Phu Phan Formation are the Three-toed footprints found in Phu Wildlife Sanctuary (Loei Province), which have been referred by Buffetaut et al. (1985) to large theropods.

The dinosaurs from the Khok Kruat Formation

The Khok Kruat Formation, according to current interpretations, forms the top of the Khorat Group. The occurrence in it of a peculiar freshwater hybodont shark, *Thaiodus rucha*, otherwise known only from the Aptian-Albian of Tibet (Cappetta et al., 1990), suggests a late Early Cretaceous age for the Khok Kruat Formation. Palynological data cited by Mouret (1994) suggest an Aptian age. The dinosaur remains found in the Khok Kruat Formation include a theropod tooth from Ban Khok Kruat, near Khorat, and jaws of the primitive ceratopsian *Psittacosaurus* from Ban Dong Bang Noi, in Chaiyaphum Province (Buffetaut et al.,

1989). The latter have been described as a new species, *Psittacosaurus sattayarakii*, by Buffetaut and Suteethorn (1992). This find extends the range of *Psittacosaurus*, which was previously known from Mongolia, Siberia and northern China, to South-East Asia.

Conclusion

The Thai record of dinosaurs is clearly the best in South East Asia, both in terms of systematic diversity and stratigraphic range (the only other reported dinosaur localities are those of southern Laos, first reported by Hoffet in the 1930s, which contain sauropods and ornithopods and may be equivalent in age to the Khok Kruat Formation of northeastern Thailand see Buffetaut, 1991). Much remains to be done in order to obtain a better knowledge of the succession of dinosaur faunas in Thailand. Very little is known of the Late Triassic forms, there now seems to be no record from the Jurassic, and the material from the Khok Kruat Formation is still scanty. The Sao Khua Formation, on the other hand, can now be considered as one of the important dinosaur-bearing formations in Asia. The revised ages now available for the Khorat Group make the Sao Khua assemblage especially interesting, since dinosaur faunas from the early (ante-Aptian) part of the Cretaceous are still poorly known in Asia. A large part of the recent finds from the Sao Khua Formation are still being prepared or are currently under study. However, what is already known reveals an original fauna dominated by sauropods which are different from those from the Jurassic of China and containing an early but already advanced representative of the Ornithomimosauria. The Sao Khua fauna is clearly of great importance for our understanding of the early stages of the Cretaceous history of dinosaurs in Asia.

References

- Bristow, C., P. Howlett, and A. Carter. 1994. Stratigraphy and sedimentology of the Khorat Group of the Vientiane Basin area of Laos and the western edge of the Khorat Plateau, NE Thailand. In: Angsuwathana, P., T. Wongwanich, W. Tansathien, S. Wongsomsak and J. Tulyatid (eds.), Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia. Department of Mineral Resources, Bangkok: 159.
- Buffetaut, E. 1991. On the age of the Cretaceous dinosaur-bearing beds of southern Laos. *Newsl. Strat.*, 24 : 59-73.
- Buffetaut, and R. Ingavat. 1984. A very small theropod from the Upper Jurassic of northeastern Thailand. *C.R. Acad. Sci. Paris*, 298, II: 915-918.
- Buffetaut, and R. Ingavat, 1986. Unusual theropod teeth from the Upper Jurassic of Phu Wiang, northeastern Thailand. *Rev. Paleobiol.*, 5: 217-220.
- Buffetaut, R. Ingavat, N. Sattayarak, and V. Suteethorn, 1985. First dinosaur footprints from South-East Asia: carnosaur tracks from the Lower Cretaceous of Thailand. *C.R. Acad. Sci. Paris*, 301, II: 643-648.
- Buffetaut, N. Sattayarak, and V. Suteethorn. 1989. A psittacosaurid dinosaur from the Cretaceous of Thailand and its implications for the palaeogeographical history of Asia. *Terra Nova*, 1 : 370-373.
- Buffetaut, and V. Suteethorn, 1989. A sauropod skeleton associated with sauropod teeth in the Upper Jurassic of Thailand. Remarks on the taphonomic and palaeoecological significance of such associations. *Palaeogeogr., Palaeoclimat., Palaeoecol.*, 73 : 77-87.
- Buffetaut, and V. Suteethorn, 1992. A new species of the ornithischian dinosaur *Psittacosaurus* from the Early Cretaceous of Thailand. *Palaeontology*, 35(4) : 801-812.
- Buffetaut, and V. Suteethorn, 1993. The dinosaur of Thailand. *Journal of Asian Earth Sciences*, 8: 1-4 : 77-82.
- Buffetaut, H. Tong, and V. Suteethorn. 1994. First post-Triassic labyrinthodont amphibian in South East Asia: a temnospondyl intercentrum from the Jurassic of Thailand. *Neues Jahrb. Geol. Palaont., Monatsh.*, 7: 385-390.
- Cappetta, H., E. Buffetaut, and V. Suteethorn. 1990. A new hybodont shark from the Lower Cretaceous of Thailand. *Neues Jahrb. Geol. Palaont., Monatsh.*, 11: 659-666.
- Martin, V., E. Buffetaut, and V. Suteethorn. 1993. Jurassic sauropod dinosaurs of Thailand: a preliminary report. In: Thanasutipitak, T. (ed.), *Biostratigraphy of mainland Southeast Asia*. Chiang Mai University, 2: 415-425.
- Martin, V., E. Buffetaut, and V. Suteethorn. 1994. A new genus of sauropod dinosaur from the Sao Khua Formation (Late Jurassic or Early Cretaceous) of northeastern Thailand. *C. R. Acad. Sci. Paris*, 319. II: 1085-1092.
- Mouret, C. 1994. Geological history of northeastern Thailand since the Carboniferous. Relations with Indochina and Carboniferous to Early Cenozoic evolution model. In: Angsuwathana, P., T. Wongwanich, W. Tansathien, S. Wongsomsak and J. Tulyatid (eds.), Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia. Department of Mineral Resources, Bangkok: 132-158.
- Polahan, M., and V. Daorerk. 1993. Report on additional discovery of dinosaur's footprints in Thailand. In: Thanasutipitak, T. (ed.), *Biostratigraphy of mainland Southeast Asia*. Chiang Mai University, 1: 225-230.
- Racey, A., J.G.S. Goodall, M.A. Love, S. Polachan, and P.D. Jones. 1994. New age data for the Mesozoic Khorat Group of Northeast Thailand. In: Angsuwathana, P., T. Wongwanich, W. Tansathien, S. Wongsomsak and J. Tulyatid (eds.) Proceedings of the International Symposium on Stratigraphic Correlation of Southeast Asia. Department of Mineral Resources, Bangkok: 245-252.
- Russell, D.A. and Z. Zheng. 1993. A large mamenchisaurid from the Junggar Basin, Xinjiang, People's Republic of China. *Can. J. Earth Sci.*, 30: 2082-2085.