

## **The succession of vertebrate faunas in the continental Mesozoic of Thailand**

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**Abstract** Fairly abundant continental vertebrate remains have been found in Mesozoic rocks in Thailand by recent Thai-French expeditions. They yield stratigraphical and palaeobiogeographical data and provide a preliminary picture of the succession of vertebrate faunas in South East Asia during the Mesozoic. Fossil vertebrates are known from late Triassic, early to middle Jurassic, late Jurassic, and early Cretaceous formations, mainly on the Khorat Plateau of northeastern Thailand. The best assemblages are from the late Triassic Huai Hin Lat Formation (with phytosaurs, turtles, stegocephalians and various fishes) and the late Jurassic Sao Khua Formation (with dinosaurs, crocodylians, turtles and fishes).

### INTRODUCTION

During the last few years, our knowledge of the continental vertebrate faunas from the Mesozoic of Thailand has vastly increased, following a series of Thai-French palaeontological expeditions which have resulted in the discovery of many new localities. Although general papers on these vertebrates have already been published (Buffetaut, 1982, 1983a, 1983b), recent new discoveries make it worthwhile to present an updated review of the succession, composition, and stratigraphical and palaeobiogeographical significance of Mesozoic vertebrate faunas from Thailand.

Most of the Mesozoic vertebrate-bearing localities of Thailand are on the Khorat Plateau, in the northeastern part of the country, where Mesozoic continental sediments (the Khorat Group) reach a thickness of several thousand metres (see Sattayarak, 1983, for a review of the continental Mesozoic of Thailand). From a palaeogeographical point of view, the Khorat Plateau belongs to the Indochina block, a microcontinent which also includes Laos, Cambodia, and most of Vietnam. A summary of the vertebrate faunas and probable ages of the formations is given in Table 1.

### LATE TRIASSIC VERTEBRATES

Fairly abundant remains of late Triassic vertebrates have been found in the Huai Hin Lat Formation, which crops out in the western part of the Khorat Plateau and is considered as the lower most unit of the Khorat Group. Fossil vertebrates from the Huai Hin Lat Formation occur in dark grey bituminous shales and limestones deposited in freshwater lakes. Several localities have been recognized (Chulabhorn Dam, Ban Loc Mai, Ban Huai Sanan Sai). The fauna identified so far includes the following forms:

Table I

## VERTEBRATE FAUNAS AND PROBABLE AGES OF THE FORMATIONS OF THE KHORAT GROUP

Formation names	Fauna	Probable stratigraphic age
Khok Kruat	Selachians, holosteans, dinosaurs	Early Cretaceous
Phu Phan		Earliest Cretaceous?
Sao Khua	Selachians, holosteans, turtles, crocodilians, coelurosaurs, carnosaurs, sauropods	Late Jurassic
Phra Wihan		Middle Jurassic?
Phu Kradung	Selachians, holosteans, turtles, crocodilians	Early Jurassic
Nam Phong		Latest Triassic to Earliest Jurassic?
Huai Hin Lat	Holosteans, lungfishes, stegocephalians, turtles, phytosaurs	Late Triassic (Norian)

—Actinopterygii: fish scales and teeth have been referred by Martin (in press) to the following forms: *Colobodus* sp., cf. *Sargodon*, and *Semionotus* sp.

—Dipnoi: *Ptychoceratodus* cf. *szechuanensis*, a lungfish represented by a tooth described by Martin and Ingavat (1982).

—Stegocephalia: *Cyclotosaurus* cf. *posthumus*, a large amphibian (Ingavat & Janvier, 1981).

—Chelonia: a primitive turtle (Broin, Ingavat, Janvier & Sattayarak, 1982), which can be referred to the genus *Proganochelys* (F. de Broin, personal communication).

—Thecodontia: numerous remains of crocodile-like reptiles of the family Phytosauridae (Buffetaut & Ingavat, 1982a), representing at least two distinct forms reminiscent of *Belodon* and *Mystriosuchus*.

This vertebrate assemblage is extremely reminiscent of late Triassic faunas from such places as Germany and North America. There are especially close links, apparently, with vertebrates from the Norian Stubensandstein of southern Germany. The vertebrates from the Huai Hin Lat Formation are therefore considered as Norian in age, which is in agreement with other stratigraphical, and palaeontological data (Buffetaut & Ingavat, 1982a; Buffetaut, 1983b).

From a palaeobiogeographical point of view, the continental vertebrates from the Huai Hin Lat Formation show Laurasian affinities (Buffetaut & Ingavat, 1982a; Martin & Ingavat, 1982; Buffetaut, 1983c), which indicate that in the late Triassic the Indochina block was already in contact with the northern land masses, whatever its previous history may have been.

In 1983, a few vertebrate remains were collected west of the Khorat Plateau near

the city of Lom Sak, in the so-called Lom Sak Formation. This formation had been referred to the late Cretaceous on palaeobotanical evidence by Japanese scientists (Iwai *et al.*, 1966). However, the newly found vertebrate remains (a phytosaur tooth and scales of the fish *Semionotus*) show that this formation is definitely older. The occurrence of a phytosaur indicates a late Triassic age, and the "Lom Sak Formation" can probably be considered as a lateral equivalent of the Huai Hin Lat Formation (Buffetaut, Ingavat & Martin, in press), which is in agreement with the stratigraphical conclusions of other authors (Bunopas, 1981).

#### EARLY TO MIDDLE JURASSIC VERTEBRATES

The Phu Kradung Formation of the Khorat Group has yielded a few vertebrate remains which may be of Liassic age, as suggested by magnetostratigraphical data (Bunopas, 1981; Maranate, 1982), although their exact position in the Jurassic is still relatively uncertain.

The best specimen hitherto discovered is a nearly complete lower jaw of a large crocodylian, *Sunosuchus thailandicus* (Buffetaut & Ingavat, 1980) from a roadcut near Nong Bua Lam Phu, on the Khorat Plateau (Buffetaut & Ingavat, 1980, 1982b, 1984). The genus *Sunosuchus* was first described from Gansu, China, and its occurrence is indicative of Laurasian faunal affinities, but its biostratigraphical value is limited, although it is in agreement with a Jurassic age.

In 1983, we collected vertebrate remains from a new locality in the Phu Kradung Formation at Ban Wang Dingso, on the highway between Phitsanulok and Lom Sak, west of the Khorat Plateau. The fossils come from a greenish conglomerate exposed in a quarry. They include fish scales and teeth, turtle plates and reptile teeth. When it is completely prepared and studied, this assemblage may yield interesting data, as Liassic continental vertebrates are poorly known everywhere.

The vertebrate remains found in 1981 at two places on Ko Kut, an island in the Gulf of Thailand close to the Cambodian border, may be mentioned here. They include teeth of hybodont sharks and of a *Lepidotes*-like actinopterygian fish, turtle plates, and reptile teeth (crocodylians). These fossils, found in a grey sandstone, are still being studied, and their stratigraphical significance is still uncertain, but some of the shark teeth seem to suggest a Liassic age.

#### LATE JURASSIC VERTEBRATES

Various remains of late Jurassic vertebrates have been collected from the Sao Khua Formation on the Khorat Plateau. Isolated bones of sauropod dinosaurs have been found in several places, near Nong Bua Lam Phu and Kalasin, but the best assemblage comes from Phu Wiang, a mountain about 70 km West of the city of Khon Kaen. There, in red and green siltstones exposed at a locality called Phu Pratu Teema, we have found a partial articulated skeleton of a sauropod dinosaur, and many isolated teeth and bones, which allow a preliminary reconstruction of the fauna. The following forms have been recognized:

—Elasmobranchii: teeth of hybodont sharks.

—Actinopterygii: teeth of *Lepidotes*.

—Chelonia: turtle plates indicating several forms.

—Crocodylia: *Goniopholis phuwiangensis* (Buffetaut & Ingavat, 1983) a mesosuchian crocodylian represented by jaw fragments and teeth.

—Saurischia: the saurischian dinosaurs are represented by various forms. The carnivorous theropods are represented by teeth of a large carnosaur and bones of a very small coelurosaur apparently closely related to *Compsognathus*, one of the smallest known dinosaurs (Buffetaut & Ingavat, in press). The sauropods are represented by an isolated tooth, isolated large limb bones, and the above-mentioned partial skeleton.

Although a large part of the material is still being prepared and studied, the vertebrate remains from Phu Wiang already indicate a floodplain community very similar to assemblages from well-known late Jurassic localities in western North America (Morrison Formation) and China (Shangshaximiao Formation of Sichuan). Its vertebrate fauna thus indicates a late Jurassic age for the Sao Khua Formation, which is in agreement with other palaeontological and magnetostratigraphical evidence (Hahn, 1982; Maranate, 1982). The occurrence of the genus *Goniopholis* apparently indicates biogeographical relations with Laurasia rather than with Gondwanaland (Buffetaut & Ingavat, 1983).

#### EARLY CRETACEOUS VERTEBRATES

A few remains of presumably early Cretaceous vertebrates have been collected from quarries in the Khok Kruat Formation at Ban Khok Kruat, near Nakhon Ratchasima on the Khorat Plateau. The fauna includes:

—Elasmobranchii: teeth of hybodont sharks.

—Actinopterygii: in 1983, we have been able to observe well preserved fossil fish apparently reminiscent of *Lepidotes*, which was then kept in a temple at Ban Khok Kruat.

—Saurischia: a few incomplete bones can be referred to a theropod dinosaur.

These fossils come from red sandstones and conglomerates probably deposited in a fluvial environment. The shark teeth are of special interest, as they indicate a hitherto undescribed form of hybodont which has also been found by J.J. Jaeger in Tibet during the recent French-Chinese expedition. The Tibetan specimens come from an Aptian-Albian formation, and the occurrence of the same peculiar freshwater shark in the Khok Kruat Formation suggests a similar age for the latter, as well as biogeographical relations between the Indochina block and Tibet in the early Cretaceous.

#### CONCLUSIONS

This brief review of the present state of our knowledge of Mesozoic vertebrates in

Thailand shows that much remains to be done, although many interesting discoveries have been made during the last few years. The Huai Hin Lat Formation and the Sao Khua Formation have both yielded relatively numerous and varied vertebrate remains, so that preliminary reconstructions of late Triassic and late Jurassic vertebrate life in Thailand are possible. The vertebrates from the Phu Kradung and Khok Kruat Formations are much more incompletely known, and more collecting is needed. Moreover, no vertebrate fossils have hitherto been collected from several potentially vertebrate-bearing formations of the Khorat Group (Nam Phong, Phra Wihan and Phu Phan Formations). Finally, most of the fossil vertebrates from the Mesozoic of Thailand come from the Khorat Plateau, although suitable continental formations are also known in other parts of the country, such as the north or the southern peninsula.

The Mesozoic vertebrate record of Thailand is the best available in all of South East Asia (a few remains have also been reported from Laos: see Buffetaut, 1981). Actually, the continental Mesozoic deposits of Thailand, ranging in age from late Triassic to late Cretaceous and containing several important vertebrate-bearing levels, have few equivalents in the world as far as vertebrate palaeontology is concerned. There is little doubt that future research will greatly improve the emerging picture of the succession of Mesozoic vertebrate faunas in Thailand that we have outlined here.

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