

New vertebrate-bearing localities in the Triassic of Thailand

Chalida Laojumpon^{1*}, Uthumporn Deesri^{1,2}, Suchada Khamha^{1,2}, Athiwat Wattanapituksakul^{1,2}, Komsorn Lauprasert^{1,2}, Suravech Suteethorn^{1,2}, Varavudh Suteethorn^{1,2}

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Abstract

Three new vertebrate localities in the Triassic of Thailand are described from the Huai Hin Lat Formation (Carnian to Norian, Late Triassic). They are noteworthy because they contain interesting vertebrate fossils including numerous coprolites, a new record of hybodont shark, rather complete bony fish remains, a phytosaur tooth and temnospondyl fragments. The abundance of vertebrate fossils at three new localities is very important for it provides a better reconstruction of Triassic environments from Thailand and can be a great source of information about the geological history of South East Asia. For this purpose, more excavations are needed.

Keywords: new vertebrate-bearing localities, Triassic, Thailand

Introduction

The discovery of vertebrate fossils in the Triassic of Thailand started when a Thai-French palaeontological team began excavations at several sites of Thailand. Many vertebrate fossils were found, ranging in age from the Late Triassic to the Early Cretaceous, in the continental rocks of the Khorat plateau. However, reports of Triassic fossil vertebrates from Thailand are still rather few. Most of the Triassic vertebrate fossils were found in the Huai Hin

Lat Formation, dated from the Late Triassic (Carnian to Norian)¹ by palynomorphs and vertebrate assemblages^{2,3,4}. The Nam Phong Formation, palynology suggests that the formation is not older than Pliensbachian (Late Early Jurassic). The numerous remains of Triassic vertebrate fossils that have been found are kept at the Sirindhorn Museum and the Palaeontological Research and Education Centre (PRC), Mahasarakham University. However, most of them have not yet been studied in detail. The biodiver-

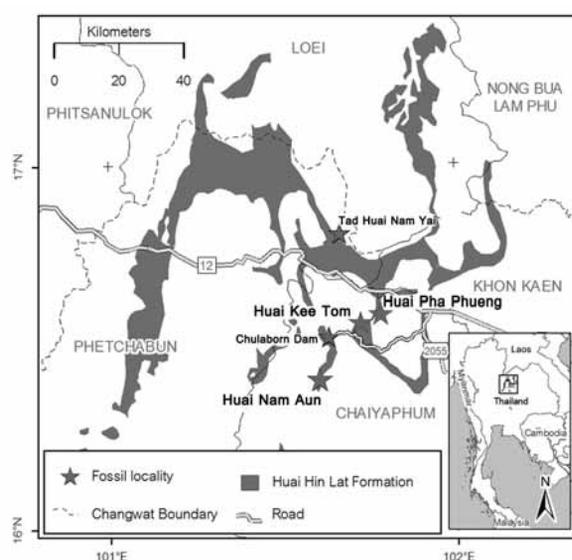


Figure 1 Vertebrate fossil localities in the Triassic Huai Hin Lat Formation of Thailand.

¹ Department of Biology, Faculty of Science, Mahasarakham University, Khantarakwichai, Mahasarakham 44150, Thailand.

² Palaeontological Research and Education Centre, Mahasarakham University, Khamrieng, Mahasarakham 44150, Thailand.

* Corresponding author: Ch.laojumpon@gmail.com

sity and evolution of vertebrates as well as the palaeoenvironment of the Triassic period in Thailand are therefore still very little known. However, in December 2010, the staff of the Palaeontological Research and Education Centre visited Chaiyaphum Province again and found three new localities of vertebrate fossils in the Triassic; Huai Nam Aun, Huai Pha Phueng and Huai Kee Tom. All of them belong to the Huai Hin Lat Formation. Here, we provide a preliminary description of the vertebrate fossils and a geological summary of these three new localities investigated during field trips in 2010-2011.



Figure 2 New localities of vertebrate fossils from this survey A: Huai Nam Aun locality, B: Huai Pha Phueng and C: Huai Kee Tom.

rocks 5; this unit is Upper Triassic (Carnian to Norian)¹ on the basis of its palynological contents^{2,3} and vertebrate assemblages⁴. These include: a shark denticle 6, a tooth of *Ferganoceratodus szechuanensis*^{7,8,9}, the amphi-bians *Cyclotosaurus cf. posthumus* and a plagiosauroid¹⁰, and phytosaurs¹¹. All of them were found at an outcrop near Chulabhorn dam, Khonsan district, Chaiyaphum Province. To this should be added the turtle *Proganochelys rucha* Broin, 1984¹² and the archosaur trackways at Tad Huai Nam Yai, near Nam Nao in Phetchabun Province^{13,14,15}. The Huai Hin Lat Formation is unconformably overlain by the Nam Phong Formation. The Nam Phong Formation consists of continental rocks formed in fluvial environments (braided and meandering channels interbedded with lacustrine or floodplain sequences)³

New localities

To the preceding list of localities, we now add three new localities of vertebrate fossils in the Triassic of Thailand (Figures 1 and 2) including:

Previously known localities

The Mesozoic sedimentary rocks of Thailand range in age from the Late Triassic to the Early Cretaceous^{2,3}. Sedimentary rocks from the Triassic period consist of the Huai Hin Lat and the Nam Phong Formations. The lowermost unit is the Huai Hin Lat Formation. This formation is composed of fluvial and lacustrine sand, silt and mudstone deposits associated with volcanic

1. Huai Kee Tom

Geological data

Huai Kee Tom is a part of Huai Pha Phueng wildlife sanctuary, Khonsan district, Chaiyaphum Province. Huai Kee Tom is about 10 km away from the Chulaborn dam locality. All of the skeletal elements were found lying on the surface of the ground. Bone beds were not found during this survey.

Vertebrate Fauna

Most of vertebrate fossils from this locality are fragmented. The following vertebrate fossils were found at Huai Kee Tom: abundant bone fragments, an incomplete archosaur tooth, fragments of turtle shell, and numerous coprolites.

Both spiral and non-spiral coprolites were found at this locality. Most of them are rather well preserve, they are about 10-35 mm in length, fairly smaller than coprolites from the Huai Nam Aun and Huai Pha Phueng localities. Most spiral coprolites from Huai Kee Tom (Figure 3B-C) are ellipsoidal, ovoid or cylindrical in

shape. The number of coils visible on the surface varies from five to eleven. Inclusions of ganoid fish scales are visible on the external surfaces of some specimens. Both the shape and external surfaces of spiral coprolites from Huai Kee Tom are similar to *Liassocopros hawkinsi* Hunt et al., 2007¹⁶, which is distributed worldwide from the Late Triassic to the Late Cretaceous¹⁶. Concerning non spiral coprolites, the overall shape varies from almost spherical to elongate ellipsoidal. The surface texture is irregular. Several fish scales are visible in some areas, suggesting that they were produced by fish-eating organisms.

The only archosaur tooth from this locality is very poorly preserved, the specimen shows only part of the crown. The surface is rather smooth; numerous denticles also show in lateral view. Ray and Chinsamy (2002)¹⁷ suggested that isolated teeth from the Late Triassic-Early Jurassic period should be treated with caution because they could belong to any of the large carnivores present at that time. These include the "thecodonts" (rauisuchians, phytosaurs, ornithosuchians and parasuchids) and the theropods (herrerasaurids and ceratosaurs). Consequently, the incompleteness of this tooth does not allow identification beyond Archosauria indet.

2. Huai Pha Phueng

Gelological data

This locality is part of a stream bed in Huai Pha Phueng wildlife sanctuary (Figure 1). The Huai Pha Phueng locality is about 1 km away from Huai Kee Tom (Figure 2). Sediment in this area consists mainly of brown, gray and black mudstone. Vertebrate fossils were found in several layers of brown and gray laminated mudstone.

Vertebrate Fauna

Vertebrate fossils from Huai Pha Phueng are a lot of coprolites, a phytosaur tooth and unidentified bony fishes. Most of them are rather well preserved.

Both spiral and non-spiral coprolites, varying in size and shape were found in several layers of Huai Pha Phueng locality. Most spiral coprolites (Figure 3A) are *L. hawkinsi*, which is also found at Huai Kee Tom locality. However, coprolites from Huai Pha Phueng are bigger than those from Huai Kee Tom locality. The overall shape of non-spiral coprolites from Huai Pha Phueng varies from almost spherical to elongate ellipsoidal. Surface texture is irregular. In addition, the absence of inclusions on their surface suggests that they were not produced by fish-eating organisms.

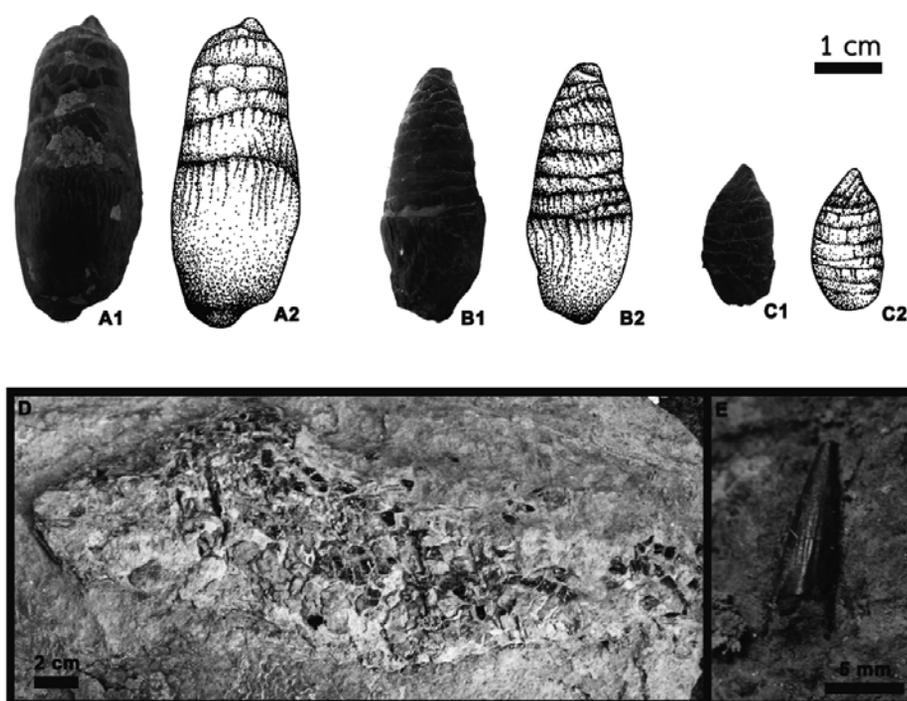


Figure 3 Vertebrate fossils from Huai Kee Tom (B-C: Spiral coprolites) and Huai Pha Phueng locality (A: Spiral coprolite, B: Bony fish specimen and C: Phytosaur tooth).

A phytosaur tooth from Huai Pha Phueng (Figure 3E) is fairly well preserved. The crown is almost complete whereas the root is missing. It is 9 mm in height. The tooth is conical in shape. The crown shows numerous straight ridges parallel to each other, which become fainter towards the base, and a number of low ridges, which tend to disappear towards the apex. Several characters of this specimen resemble the isolated tooth number HHL1-9.3, which is housed at Sirindhorn museum. Katisat¹⁸ suggested that isolated tooth number HHL1-9.3 should be an anterior tooth of a phytosaur. Thus, the tooth from Huai Pha Phueng is probably be an anterior tooth of a phytosaur.

Bony fishes from this locality are very interesting and rather well preserved. Few specimens show both the skull and several parts of the body (Figure 3D). Results from a preliminary study by Bumrungsap¹⁹ indicated that the bonyfishes from Huai Pha Phueng are Macrosemiiformes and Semionotiformes. Comparison with vertebrate specimens from the other formation of the Khorat Group suggests that the bony fishes from Huai Pha Phueng are very different from those from other localities in Thailand¹⁹.

All the fish specimens are now being studied in detail to better understand their taxonomy, evolution and palaeogeography.

3. Huai Nam Aun Locality Geological data

Huai Nam Aun is situated near the village called Nongyakong (Ban Nongyakong), Khonsan district, Chaiyaphum province (Figures 1 and 2). Sediment in this locality contains various layers of limestone and mudstone. The lowest layer of the outcrop consists of dark limestone with chert nodules overlain by dark calcareous mudstones with fossil algae. Finally, the upper part of the outcrop contains thinly (0.5-2 cm) laminated beds of calcareous mudstone. In these beds, we found a lot of vertebrates fossils, especially coprolites. The lithology suggests that it was deposited in brackish water near a calcium carbonate source (e.g., pond near coastline) with more or less anoxic conditions during the deposition of the basal layers.

Vertebrate Fauna

All vertebrate fossils from this locality were found in calcareous mudstone layers. Huai Nam Aun has produced abundant coprolite material and a lot of skeletal remains including a *Hybodus* tooth, bony fish scales and temnospondyl fragments.

Most coprolites from Huai Nam Aun locality (Figure 4K-Q) were preliminarily identified by Laojumpon et al.2012. All of them were subdivided into seven different groups of ichnotaxa including 3 of non-spiral and 4 of spiral type. Most coprolites in this locality are spiral coprolites belonging to *L. hawkinsi*²⁰ which is distributed from the Late Triassic to the Late Cretaceous of Europe, India and North America. Moreover, we also found *Sauropros bucklandi* Hunt et al, 2007¹⁶ which is abundant in the Late Triassic (Carnian-Norian) and the Early Jurassic¹⁶. Concerning non-spiral coprolites, they are very various in size and shape. However, the occurrence of many bony fish scales and bone fragments in several specimens implies that they have been produced by a carnivorous vertebrate²⁰.

The most spectacular element from Huai Nam Aun is a shark tooth (Figure 4A) which was found by S.K., because this is the first record of a hybodont shark tooth from the Triassic of Thailand. It is 4 mm labiolingually and 2 mm high at the level of the main cusp. The tooth shows a high main cusp and two pairs of lateral cusplets. The crown surface is covered by numerous strong ridges, quite straight, running from the base to the apex of the crown. Although detailed comparisons have not yet been performed, it can be said that the shark tooth from Huai Nam Aun shows similarities with *Hybodus*. From a palaeobio-geographical and chronological point of view, many *Hybodus* species were described world-wide on the basis of teeth or more or less complete skeletons. The genus ranges from Middle Triassic to Late Cretaceous^{21,22}.

Most of the bony fish remains from this locality are scales and bone fragments. Fish scales from this locality can be divided into two groups. The first group (Figures 4B and 4D) is rectangular in outline, rather elongated and almost flat. The surface is ornamented by numerous densely packed and deep ridges, running along the axis of the scale. Most isolated scales present a socket for the peg and socket articulation

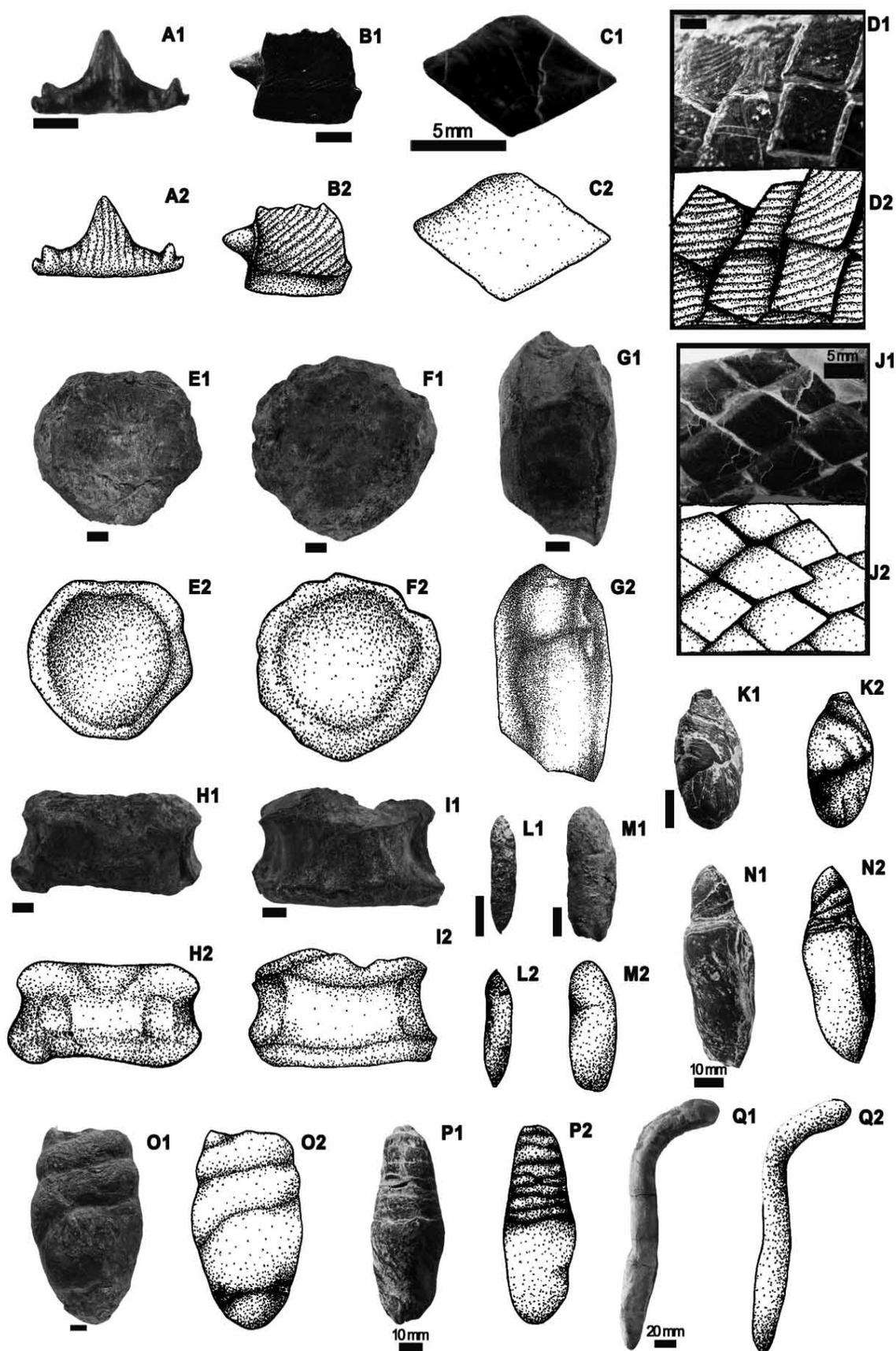


Figure 4 Vertebrate fossils from Huai Nam Aun locality (A: *Hybodus* tooth, B-D and J: Fish scales, E-I : Temnospondyl vertebrae and K-Q: Coprolites. All scale bars: 1 cm, except C, J, N, P and Q).

between scales (Figure 4B). Based on the characters above, this group is identifiable as aff. *Paleoniscidae*. The second group (Figures 4C and 4E) shows a rhombic shape in apical view. The surfaces are rather flat and smooth. Brito and Gallo, 2002²³ suggested that semionotid fish scales are normally unornamented, slender, and composed of ganoine. Thus this group possibly corresponds to semionotid fishes. We also found many temnospondyl bones (Figure 4E-H) in this area.

Unfortunately, most specimens are very fragmented. The most complete specimen is an intercentrum. This intercentrum is rather massive, pleurocentra are absent. The outline of the intercentrum is almost circular in anterior and posterior views, the horizontal diameters are about 50 mm in anterior view and 65 mm in posterior view. Both the anterior and posterior surfaces of the intercentrum are rather concave but the posterior articular facet is more concave. A massive intercentrum and small pleurocentra or an absence of pleurocentra is a character of the vertebrae of *Stereospondyli*²⁴. In 1981, the amphibian *Cyclotosaurus cf. posthumus* was found near Chulaborn dam, Chaiyaphum Province¹⁰. Chulaborn dam is less than 20 km away from Huai Nam Aun. Thus, the intercentrum from Huai Nam Aun locality probably belongs to *Capitosauridae*.

Discussions and Conclusion

Preliminary surveys in Triassic areas by the staff of the Palaeontological Research and Education Centre (PRC), Mahasarakham University, with the Thai-French palaeontological team in 2010-2011 found new three vertebrate localities at Huai Kee Tom, Huai Pha Phueng and Huai Nam Aun.

Although the fossiliferous layer and complete fossils were not found at Huai Kee Tom, the archosaur tooth found at this locality were important evidence in terms of palaeontology because our knowledge about archosaurs from the Triassic of Thailand is still limited. Only a few scientific papers were published so far, such as the description of two jaw fragments of a phytosaur by Buffetaut and Ingavat¹¹. Thus, Huai Kee Tom may become an important locality for Triassic archosaurs from Thailand in the future and more surveys are needed.

In the case of Huai Pha Phueng, this locality yielded a lot of important data, especially about actinopterygian fishes. Numerous actinopterygian fishes found in this locality are very interesting because most of them are rather complete and can be studied in detail. Many actinopterygian fishes have been reported from Mesozoic sediments in various parts of Thailand⁹. Most of them were found in Late Jurassic to Early Cretaceous sediments, whereas from the Triassic there was only one report about actinopterygian fishes, by Buffetaut, Ingavat and Martin²⁵. Therefore, the actinopterygian specimens from Huai Pha Phueng locality will provide important evidence to increase our knowledge about the evolution and distribution of the Actinopterygii in Thailand during the Triassic.

Many interesting specimens were found at Huai Nam Aun locality. The discovery of a tooth of a hybodont shark and of abundant spiral coprolites, which are generally produced by sharks or rays^{26, 27, 28, 29}, indicates that Huai Nam Aun is an important locality for the study of chondrichthyan fishes from the Triassic of Thailand, because only one report about a shark denticle from the Triassic of Thailand has hitherto been published⁶. Thus this new evidence will help us to better understand the Triassic chondrichthyan fishes of Thailand.

Concerning bony fish remains, although no complete specimen was found during this survey of Huai Nam Aun locality, further comparisons will be needed for both the first and second group of isolated scales, because genus-level identification of some palaeoniscid fishes is possible on the basis of their highly varied scale ornamentation³⁰. Thus the first group can probably be identified at the genus level, whereas the second group, which presents semionotid characters should be compared with semionotid fishes from other parts of Thailand, because semionotid scale are widespread in the Mesozoic of Thailand⁹. Moreover, semionotid scales were discovered in the Triassic of Thailand in 1984, at a rock exposure between Km 105 and 122.5 along the Phitsanulok-Lomsak highway, Phetchabun Province. All the fish scales from that locality were described as *Semionotus* sp., which is distributed worldwide in the middle Triassic – early Jurassic²⁶. More comparison with

semionotid fishes from other parts of Thailand should help us increase our knowledge of the evolution of semionotid fishes in Thailand from the Triassic until the Early Cretaceous.

The three new localities, Huai Kee Tom, Huai Pha Phueng and Huai Nan Aun, are not more than 20 Km from each other. Our results indicate that the continental Triassic rocks of Thailand, especially in Chaiyaphum Province, contain abundant fossil vertebrate localities. Each locality helps us to understand several topics. Comparisons between specimens from Huai Kee Tom, Huai Pha Phueng and Huai Nan Aun and other localities are still needed to assess their possible relationships with finds from other parts of the world, in particular those described from the Triassic beds in China, and more generally to draw conclusions about their palaeobiogeographical significance. Additionally, the abundance of vertebrate fossils at Huai Kee Tom, Huai Pha Phueng and Huai Nan Aun is very important to provide a better reconstruction of Triassic environments in Thailand and can be a great source of information about the geological history of South East Asia. For this purpose, more excavations are needed.

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