

First discovery of a juvenile *Thaichthys* (Actinopterygii: Holostei) from the Late Jurassic - Early Cretaceous of Thailand

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Abstract

An isolated articulated specimen referred to *Thaichthys buddhabutrensis* from the Kham Phok locality, Phu Kradung Formation, is described. It represents the first occurrence of a juvenile ginglymodian found in the Mesozoic of Thailand. The specimen is approximately 15 cm long, 7 cm wide, and lacks the tail. The head is 3.5 cm long, and 4 cm wide. The ossifications of the head have no ornamentation, except small pits for the sensory canal. The squamation is composed of articulated ganoid scales with smooth surface. Only the paired fins are present. However, we can estimate the position of the dorsal and anal fins by examination of the pattern of the scales along the dorsal ridge and by the position of the unusual shaped anal scale, respectively. The scales show a variety of shape according to their position and some show peg and socket articulations. The size of the specimen is about three times smaller than the common size of the *T. buddhabutrensis* specimens present in the Phu Nam Jun locality from the Phu Kradung Formation. According to its size and its characteristic, the specimen described herein is referred to a juvenile individual of *T. buddhabutrensis*.

Keywords: Phu Kradung Formation, Khorat Group, ginglymodian

Introduction

The well-known fish locality of Phu Nam Jun¹, from the Late Jurassic to Early Cretaceous Phu Kradung Formation, has yielded numerous ginglymodian fishes. The largest specimen from this locality, ca. 90 cm in total length, belongs to the genus *Isanichthys*², but most of the specimens are referred to *Thaichthys buddhabutrensis*^{3,4}. This species has a total length ranging from ca. 40 to 50 cm. In November 2010, a nearly complete fish was collected from the Kham Phok locality close to the Kham Phok village, Nong Sung District, Mukdahan Province, located in NE Thailand on the Khorat Plateau (Figure 1).

Stratigraphically, the Kham Phok area is in the upper part of the Phu Kradung Formation, which is characterized by sandstone beds alternating with silty to claystone. The fish remains has been found in a greenish grey silts located just a few centimetres under the surface along the sideways. The specimen itself was enclosed in highly compact calcareous siltstone which was worked with acid and then, because of its size and fragility, mechanically prepared under a binocular. The preparation was performed in the Palaeontological Research Centre (PRC) and the specimen is now housed in the PRC collection with the collection number PRC83. After preparation (especially the skull part), the specimen was visible from both sides.

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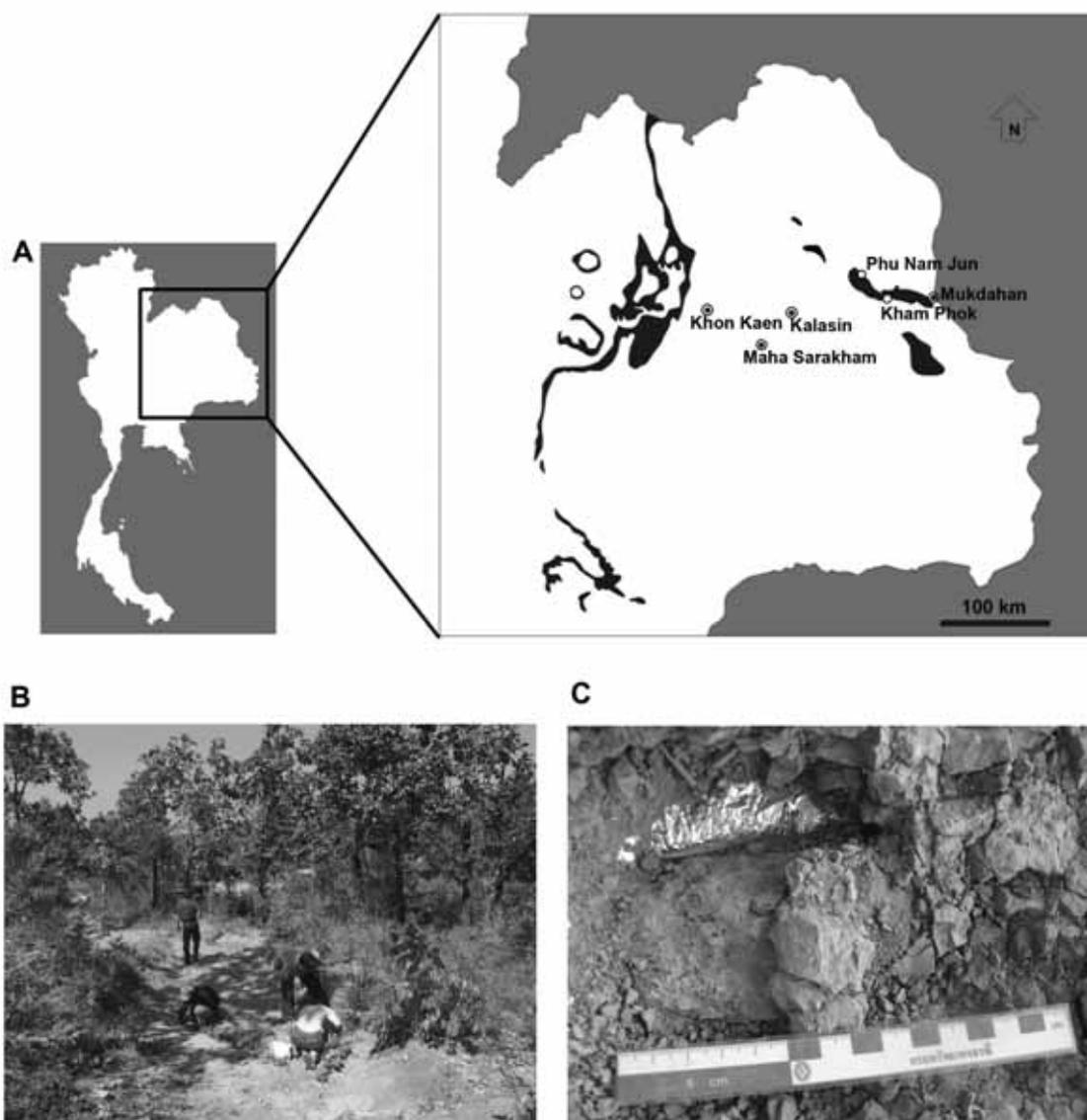


Figure 1 A: Localization of the Kham Phok locality with outcrops of the Phu Kradung Formation in black; B: The outcrop with the vegetation surrounding; and C: Photograph of the posterior part of PRC83 within the plaster jacket.

Geological setting

The specimen described in the present paper, a small ginglymodian, was found in an outcrop of fluvial grey sandy clays of the Phu Kradung Formation near the village of Kham Phok, in the Mukdahan Province, north-eastern Thailand. It was discovered in a greenish grey lens of siltstone just a few centimetres under the surface, but the specimen itself was enclosed in highly compact calcareous siltstone. The site has also yielded two large cryptodiran turtles⁵, a tibia of a theropod⁶ as well as fragments of hybodont fin spines and teeth⁷. Fragments of crocodile bones, crushing teeth of actinopterygians and

an ornithischian tooth were also found. Other vertebrate fossils found in a nearby outcrop of the Phu Kradung Formation include a lower jaw of a large crocodylian⁸, and caudal vertebrae of a *Mamenchisaurus*-like sauropod⁶.

The Phu Kradung Formation is the basal formation of the Khorat Group⁹. Its thickness varies from 1200 m in the basin centre to around 500 m on its South flanks¹⁰. It consists of fluvial sandstones, siltstones and mudstones and is dated as either Late Jurassic based on fossil vertebrates evidence^{5,6} or Early Cretaceous on the basis of palynology⁹ and detrital zircon thermochronology¹¹.

The stratigraphic position of the Kham Phok site within the Phu Kradung Formation is difficult to determine due to the complex topographic situation of the area, with the presence of rock falls and heavy weathering that prevent any clear positioning. However, it is clearly located inside the upper part of the Phu Kradung Formation, approximately at the same level as the Phu Nam Jun locality, which is located just below a Phra Wihan (Berriasian) sandstone bed.

Systematic palaeontology

Super Division Holostei *sensu* Grande 2010¹²

Division Ginglymodi *sensu* Grande 2010¹²

Order Lepisosteiformes *sensu* Cavin, Deesri and Suteethorn 2013⁴

Genus *Thaichthys* Cavin, Deesri and Suteethorn 2013⁴

Type species.–*Thaichthys buddhabutrens* (Cavin, Suteethorn, Khansubha, Buffetaut and Tong 2003)³ Figure 2-4

Material PRC83 is a nearly complete fish with only unpaired fins missing, and with an estimated total length of less than 20 cm. It shows scattered scales in the centre of its squamation, but the dorsal and ventral portions are well articulated. The dermal ossifications are better preserved on the left side; only part of the snout region is crushed, and some bones of the opercular series are not preserved. Moreover, the circumorbital ossifications are slightly shifted. On the right side, dermal bones are partly in place, but they are mostly destroyed and fragmentary. The skull ossifications are smooth without any ornamentation. The nomenclature used in the descrip-

tion follows Grande (2010)¹².

Description

General features and proportions (Figure 2).– The specimen PRC83 is a small ginglymodian fish (ca. 150 mm of estimated standard length), with a proportionally deep body (70 mm of maximum body depth). The head is 35 mm long including the opercular series, and 40 mm deep at the extrascapular level. The skull roof shows a very deep angle with the ventral part, making the general outline triangular in shape. The orbit is relatively small with a longitudinal diameter of 5 mm, which corresponds to a head/orbit ratio of 7. The ossifications of the head have no ornamentation, except small pits corresponding to the path of the sensory canals visible on the infraorbitals, dermosphenotic and the preopercle. This fish has a relatively small head compared with the deep squamation; it has a rather steep inclined dorsal outline from the anterior tip to the row of the dorsal median scales. The ventral margin of the squamation is approximately straight except the region between the head and the abdominal region, which shows a concave outline. However, this situation may be due to a preservation bias, as shows the location of the pectoral fin situated backwards. The insertion of the dorsal fin is approximately opposite to the pelvic fin. The dorsal median scales show a unique character: a longitudinal ridge at the centre of the scale with a posterior end seemingly bearing a short spine. There are two large pre-anal scales situated in front of the insertion of anal fin. The scales at the level of postcranium are in average squarish in shape, with those from the ventral and posterior parts of the body extremely elongated.

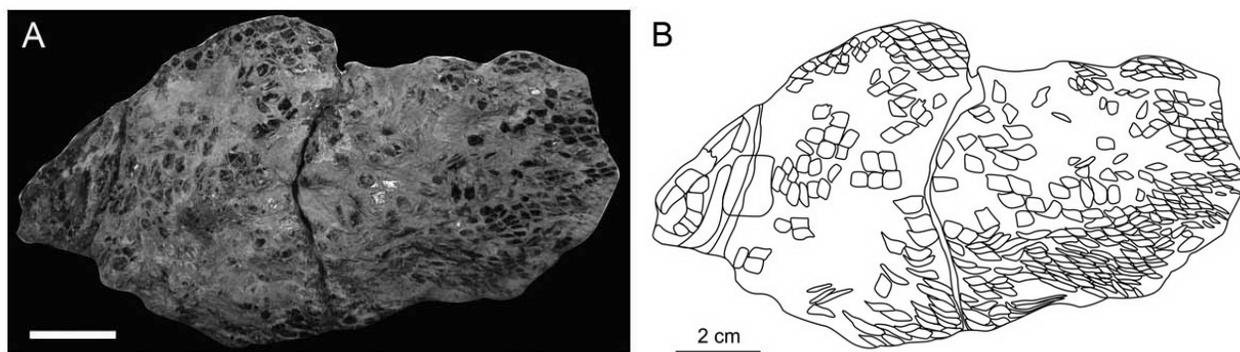


Figure 2 The skull and squamation of juvenile *Thaichthys buddhabutrens*, PRC83. A, photograph; B, line drawing.

Skull roof(Figure 3). The frontal is relatively elongated and rectangular, and is slightly broader anteriorly than posteriorly on its preserved portion. Its anterior end bears a constriction at the center and a zig zag posterior suture. At the level of the constriction of the anterior part of the frontal, a slender tube with an open hole is visible, indicating the path of the supraorbital sensory canal. The median suture of the frontal is straight. The length of the frontal is approximately 20 mm long, which is a little more than two times its width. The surface of the bone has no trace of ornamentation. The parietal and the dermopterotic are tightly connected together with a straight suture. The parietal is rather elongated with a smooth surface. The parietal is rectangular in shape, about 2.5 times longer than wide (measured from the shifted right one). The

dermopterotic is relatively small compared to the parietal; it is a small rectangular ossification with several pits for the sensory canal present at its lateral edge. Two pairs of extrascapulars are present, with the medial one much smaller than the lateral one. Because they are crushed and broken, the extrascapulars are rather fragmentary and their shape is difficult to estimate: the lateral one shows a large rounded shape with its margin suturing to the posttemporal posteriorly, to the median extrascapular dorsally and to the dermopterotic anteriorly. Their surface is smooth. The lateral extrascapular bears small pits for the path of occipital sensory canal that extends through the posttemporal bone, and the medial extrascapulars bears pits for the supratemporal commissure.

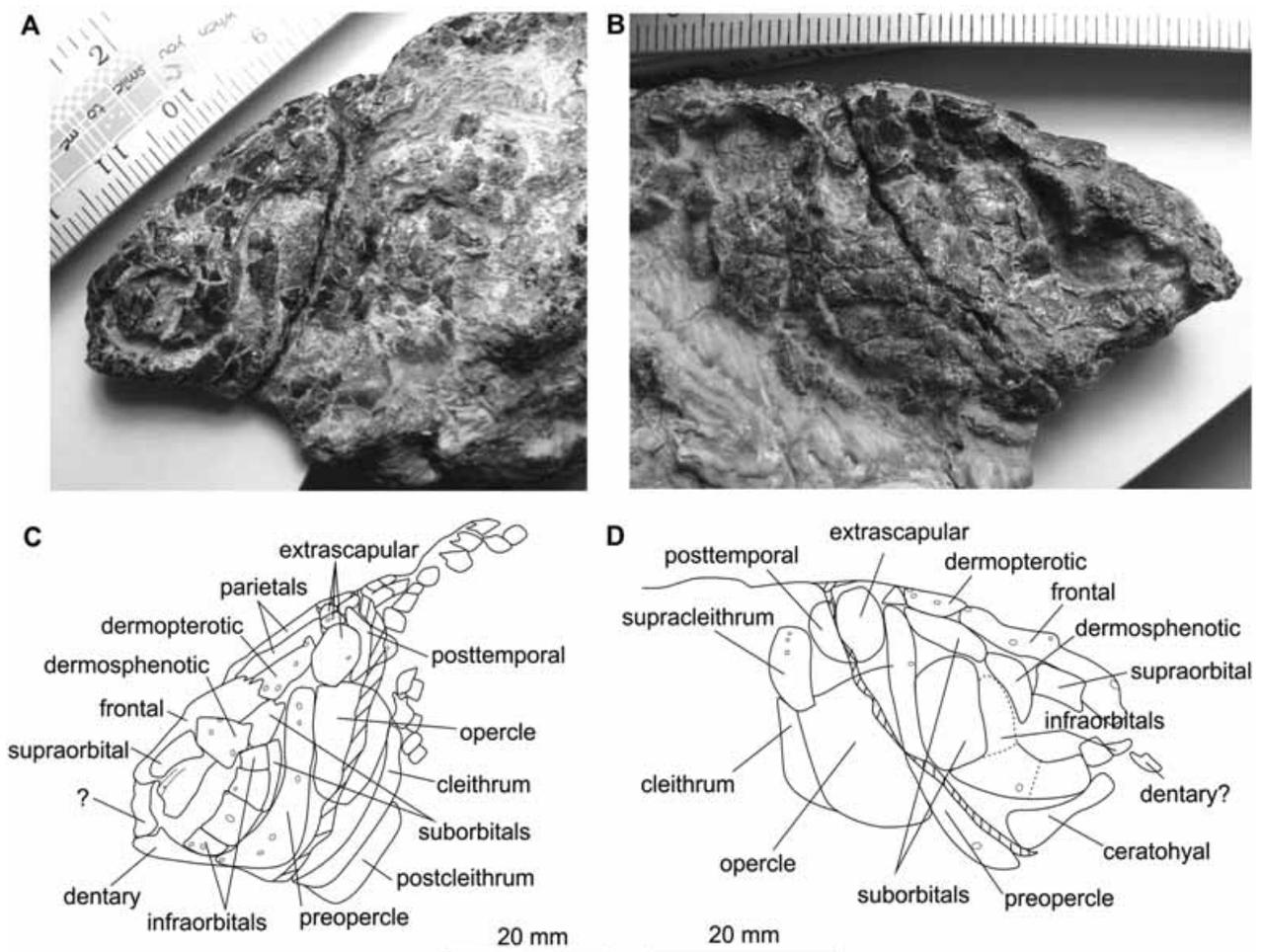


Figure 3 Skull of juvenile *Thaiichthys buddhabutrensisi*, PRC83. A,B; photographs; C,D; semi-interpretative line drawing of the left and right. The shade area corresponds to the broken fracture lines.

Circumorbital and suborbital series (Figure 3). The circumorbital series is composed of a supraorbital, a large dermosphenotic, and at least four infraorbitals located ventrally and posteriorly to the orbit but the circumorbital ring is seemingly not completely closed. One anterior infraorbital has no contact with the orbit. The first, anteriormost infraorbital is subrectangular in shape with its ventral margin gently curved. The surface of this bone is smooth, with two pits for the infraorbital sensory canal excavated on the anteroventral corner and on the centre of bone. The second infraorbital is approximately rectangular and is longer than deep with its dorsal margin showing a concavity while the other margins are straight. The surface of the ossification is smooth and it bears two pits of the infraorbital sensory canal, one on the centre of the bone and a much smaller second one on the postero-dorsal corner. The third and the fourth infraorbitals on the left side are preserved above the ventral suborbital; they are approximately rectangular with their margin apparently concave, following the shape of the orbit. The fourth infraorbital is the smallest circumorbital bone; it is articulated with the adjacent infraorbital ventrally and with the dorsal suborbital posteriorly. The shape of the dermosphenotic is roughly rectangular, with its anterior margin concave, following the shape of the orbit. At its posteroventral corner, there is apparently a deep notch for the opening of a sensory canal. Although the left ossification has shifted a little bit and is lying above the frontal, we can assume that it was located at the posterodorsal corner of the orbit as visible on the other side. It articulates probably with the supraorbital anteriorly, the suborbital posteriorly and the posteriormost infraorbital ventrally. Only one supraorbital is preserved on this specimen; it is located dorsal to the orbit, and is lying on the ventral half depth of the frontal on the left side. The supraorbital is relatively elongated and rectangular, but its posterior portion is slightly broader than the anterior one on the preserved portion. There are two suborbitals located in front of the vertical arm of the preopercle. Their shapes are rectangular but the dorsal one is smaller than the ventral one and is slightly longer than wide, while the ventral one is much larger and it is

deeper than long. The dorsal suborbital articulates dorsally with the frontal.

Jaws. The snout region is very fragmentary. The dentary is apparently present, with its visible part showing a narrow and elongate posterior portion whereas the anterior portion shows a blade-like horizontal part. Unfortunately, we cannot observe any teeth on the bone. *Opercular series.* The opercular series is better preserved on the left side, with only the preopercle and the opercle visible (Figure 3).

The preopercle is a distinctly L-shaped bone (its height is 23 mm and it is 10 mm long) but not on the right side where it is more curved probably because of distortion. The vertical arm is narrow with parallel lateral margins, except the posterior margin at the half depth of the bone which shows a little constriction, making slightly narrower the mid-depth of bone. The ventral arm is quite short with its dorsal margin gently concave and the posterior margin gently convex, making a slightly broader angle between the vertical and horizontal arms. There is no tapering dorsally and the ossification ends anteriorly as a blunt spine. A series of pores located in the centre of the bone represent the preopercular sensory canal. The opercle is relatively rectangular in shape, about 1.5 times deeper than wide (9 x 14 mm). The anterior border is straight, while the posterior border is rather convex. The dorsal and ventral margins are not clearly observable as the bone is very damaged but we can assume that they are tapering. The external surface is smooth.

Hyoid arch and branchiostegal rays. Because of the poor preservation, the branchiostegal rays are not visible. The ceratohyal is visible on the right side; it is hourglass-shaped, with its dorsal and ventral margins gently concave. Its anterior portion is smaller than its posterior portion. According to its shape, we regard it as the anterior ceratohyal (Figure 3).

Pectoral girdle. The supracleithrum is visible on the right side; its shape is subrectangular. It sutures with the posttemporal dorsally, and its surface bears at least three small pits for the sensory canal of the lateral line. The cleithrum is visible on both sides and they are present as a large crescent-shaped ossifications.

Cephalic sensory canal. The supraorbital sensory canal is visible as just one opening at the tube-like region of the anterior constriction of the frontal and then it is visible as a series of small pits on the dermopterotic. The path of the infraorbital sensory canal is visible as a series of small pits running close the dorsal margin of the infraorbitals, and then going through the dermosphenotic. The preopercular sensory canal is visible on the center of the preopercle, then at the connexion with the dermopterotic. The supratemporal sensory canal runs through the median and lateral extrascapular and then extends as the lateral line to the posttemporal and through scales, where it is present as small pit on the scales. There is no evidence of a sensory canal running within the supraorbital bones.

Pectoral fins (Figure 2).– It is difficult to reconstruct the pectoral fins as they are fragmentary, but we know at least that they present segmented rays. However, we cannot estimate how many they were because of the poor preservation.

Pelvic fins.–The pelvic fins are located approximately at half-length between the pectoral and anal fins (Figure 4). According to what can be seen, they present unsegmented rays, at least in their basal portions. The total number of the pelvic fin rays is difficult to reconstruct.

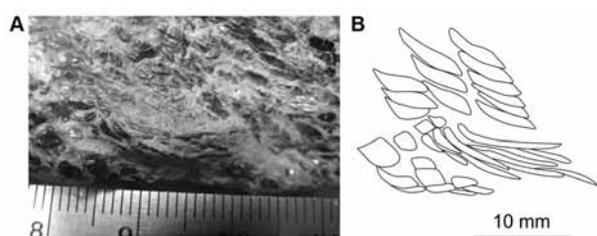


Figure 4 The left pelvic fin of juvenile *Thaiichthys buddhabutrensis*, PRC83. **A**, photograph; **B**, line drawing.

Unpaired fins.–The dorsal and anal fins are not preserved but we suggest that the dorsal fin was situated just opposite to the pelvic fin similarly than in *T. buddhabutrensis*. However the complete shape and total composition is difficult to estimate because it is broken. We recognize the origin of the anal fin from the presence

of pre-anal scales, but its exact shape and the number of rays are very difficult to identify because this part is damaged.

Squamation (Figure 2).– the body is covered with very thin and smooth ganoid scales, which present the typical ginglymodian peg and socket articulation. Most ginglymodian scales possess an anterodorsal and an anteroventral processes^{13,14}. On our specimen, the anterior margin of each scale probably presents only the anterior ventral process. However, the dorsal articulation is seemingly present only at the dorsal half portion of the body, but not in the ventral portion, and shows very elongated scales with only an anterior spine corresponding to the anterior ventral process. The lateral line scales present a pore on their surface but the exact number of lateral line scales is impossible to determine. It is the same condition with the median dorsal scales row but we know, however, that they show a very unique character, i.e. a roof-like structure at the centre of each scale with a posterior spine. Ventrally, the ventral mid line scales also present a different pattern than the adjacent scales because they show a notch at the centre of their posterior margin. There are two larger scales, compared with the adjacent ones, which are here regarded as the pre-anal scales.

Comparison and Discussion

The specimen PRC83 from Kham Phok is a small-sized ginglymodian fish of up to ca 15 cm in estimated standard length (SL) with the following combination of morphological features: skull roof marks a very deep angle in lateral view; skull bones smooth, lacking ornamentation; frontal broad anteriorly; small orbit, ratio of skull length to orbit length ca 7; open orbital ring; few infraorbitals with enlarged ventroposterior infraorbital contacting the preopercle; one elongate supraorbital; large dermosphenotic; 2 suborbitals; preopercle with two limbs arranged at an approximately right angle, the horizontal branch is much shorter than the vertical one; two pairs of extrascapulars; large posttemporal; median dorsal row of scales with short posterior spine; dorsal fins located opposite to the pelvic fin, two large preanal scales.

PRC83 can be compared with three Thai species of ginglymodians found in the Phu Kradung Formation, which are known by well-preserved material: *Thaiichthys buddhabutrensis* and *Isanichthys palustris* from Phu Nam Jun and *I. lertboosi* from Phu Noi¹⁵. PRC83 shares similar characteristics with *T. buddhabutrensis*, such as a preopercle with two limbs arranged at an approximately right angle; two pairs of extrascapulars with an enlarged lateral one; a large dermosphenotic; two suborbitals; a cheek region completely covered by bones, with an enlarged infraorbital, which contacts the preopercle; a dorsal fin located almost opposite to the pelvic ones; slightly conspicuous dorsal median ridge scales; two large preanal scales. But there are also some differences with *T. buddhabutrensis*, such as its small size, ca 15 cm in standard length, whereas the specimens of *Thaiichthys* are ca 50 cm SL; the circumorbital is not completely closed; there is only one supraorbital in PRC83 whereas there are two supraorbitals in *T. buddhabutrensis*; the frontal is broader anteriorly in PRC83 whereas it is roughly rectangular in *T. buddhabutrensis*. PRC83 differs from *Isanichthys palustris* by its much smaller size, ca 15 cm in standard length whereas *I. palustris* is ca 90 cm SL; its long frontal which broadens anteriorly while it slightly tapers anteriorly in *Isanichthys*; its infraorbitals that contact the preopercle whilst none of the infraorbitals contact the preopercle in *Isanichthys*; its preopercle with two limbs arranged at an approximately right angle whereas it is gently curved in *Isanichthys*.

Based on the shared characteristics between PRC83, which is small in size, and the specimens of *Thaiichthys buddhabutrensis*, PRC83 is regarded as a juvenile individual of *Thaiichthys*. Some of the observed differences between the specimen from Kham Phok and those from Phu Nam Jun are possibly caused by preservation but, because of the juvenile status of PRC83, some ossifications may not have completely ossified, such as bones of the circumorbital ring.

Conclusion

Several hundred *Thaiichthys* specimens have been discovered in the Phu Nam Jun locality. The analysis of the size range shows that they all belong to a single population¹⁶ but, strangely enough, there is no evidence of juvenile specimens. The specimen described above is the first occurrence of a small ginglymodian from the Jurassic and Cretaceous of Thailand, and it is regarded as a juvenile of *Thaiichthys buddhabutrensis*. However, because this conclusion is based on a single articulated specimen, and because this specimen shows some differences with *T. buddhabutrensis* from Phu Nam Jun, we cannot exclude that it belongs to a new taxon, which could be defined when more material will be found.

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