

**The first Mesozoic frog from China (Amphibia: Anura),
Liaobatrachus grabau gen. et sp. nov.**

by

Shu'an Ji and Qiang Ji

Geological Museum of China

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Translated By Will Downs
Bilby Research Center
Northern Arizona University
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Introduction*

The Salientia is regarded the the most derived rank of extant Amphibia, being not only taxonomically diverse, but also extensively widespread. To date, Chinese fossil anurans are known only from the Tertiary and Quaternary, the most notable of which are the taxa *Rana basaltica* and *Macropelobates cratus* from the Miocene Shanwang Fm. of Shandong Province. This text describes a fossil anuran from the late Late Jurassic lower Yixian Fm. produced from the locality of Sihetun, Shangyuan, Beipiao Municipality, western Liaoning Province. The specimen represents the first discovery of Mesozoic Anura in China, is the oldest member of the order in East Asia, and fills a vacancy regarding the presence of anurans on the Jurassic continents. The specimen is not only an addition to the prolific Jehol Fauna of western Liaoning, it moreover is extremely significant toward the understanding of archaic anuran morphology, phylogeny, and paleogeography.

Specimen Description

Class Amphibia Linnaeus, 1758

Subclass Lissamphibia Haeckel, 1866

Order Anura Rafinesque, 1815

Family Pelobatidae Bonaparte, 1850

Genus *Liaobatrachus* gen. nov.

Etymology: Genus nomenclature *Liao*, being a contraction for Liaoning Province, and *batrachus* being the frequently used suffix for fossil anuran genera.

Genus diagnosis: Moderate in size (length from rostrum to pelvic girdle: 75 mm), cranium broad and spacious, maxilla with a densely-packed pedicellate dentition, and frontals fused with parietals. Nine presacral vertebrae are present, the majority of which are procoelous, diapophyses on vertebrae II-IV are relatively long whereas those on the sacrum are expansive and fan-shaped. Urostyle length exceeds that of the presacral vertebral column, and urostyle diapophyses are present anteriorly. Pectoral girdle is arcuate and clavicle is strongly curved. Forelimb is short and thick, pelvic girdle is elongated, hind limb is elongated with tibia and fibula equivalent in length to the femur, and lengths of tarsalia exceed half the length of the tibia-fibula.

***Liaobatrachus grabau* gen. et sp. nov.**

(Plate I, Figure 1 and Text-figure 1)

Species etymology: Named in honor of Professor Amadeus W. Grabau, the eminent Chinese scholar who conducted significant research upon the Jehol Fauna in the early 20th century.

Type: A relatively complete skeleton (Geological Museum of China #GMV2126).

Locality and stratigraphic position: Late Jurassic lower Yixian Fm., at the locality of Sihetun, Beipiao Municipality, Liaoning Province.

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Specimen description

Only a portion of the cranial elements is preserved, but it is estimated that the cranium is broad and spacious with an approximate breadth of 33 mm and an anteroposterior length that does not exceed 25 mm. Anterior margin of the fused frontoparietals is slightly medially concave, the anteroposterior length is 8-9 mm, anterior breadth is 6 mm, and posteriorly these gradually narrow. The prootic is relatively large, irregularly pentagonal in morphology, lateral sides are relatively short, and length and breadth are both approximately 6 mm. The pterygoid is trifoliate in morphology. The dorsal margin of the left maxilla maintains two relatively conspicuous processes: the anterior palatine process, which is relatively small, and the posterior jugal or zygomatic process, being rather extended to represent the most elevated point of the maxilla. The right maxilla has suffered damage but is 14 mm in length. The ventral margin is 11.5 mm in length and bears 31 densely packed, nearly 1 mm long, pedicellate teeth. The right mandible has minor curvature, is anteroposteriorly elongated, and relatively expanded posteriorly.

The entire vertebral column is relatively well preserved, with each vertebra maintaining distinct diapophyses. The presacral column length is 21 mm and is composed of nine vertebrae, but the morphology of the anterior and posterior articular surfaces is vague, although they appear to be procoelous. Each vertebra is distinctly broader than long. It appears that the first cervical is not fused to the second. Diapophyses on the second through fourth vertebrae are relatively long, broad, and slightly posteriorly oblique with expanded lateral termini and constricted midsections. The diapophyses on the left side of the third and fourth vertebra are relatively well preserved, extending laterally 5-5.5 mm. Diapophyses on the fifth through ninth vertebrae are relatively small, extending only approximately 2.5 mm with unconstricted midsections and reduced and rounded termini. The single sacral vertebra is procoelous with large, expanded fan-shaped diapophyses. Diameter of these arcuate diapophyseal termini is 6 mm, as is their length. The urostyle is thick and elongated, being 23 mm in length, which exceeds the length of the presacral column. Anterior and midsection breadth is approximately 2 mm, and the shaft does not distinctly attenuate posteriorly. 1-mm broad urostyle diapophyses are present anterolaterally.

Elements representing the pectoral girdle and forelimb include a right humerus, anterior to which lie a poorly preserved scapula and suprascapula. The scapula is long and plate-shaped, the suprascapula is equivalent in size to the scapula with a relatively narrow terminus that lies distant from the main body. The coracoid is 6 mm in length, its medial terminus is approximately 1.5 mm in breadth, midsection is basically not constricted, and lateral terminus abruptly expands to a 4-mm breadth. The clavicle is slender and arcuate. Therefore, based upon its morphology in addition to that of the medial terminus of the right coracoid, it is determined that the pectoral girdle represents the arcuate or arciferous state.

The forelimb is relatively short and robust with a robust humerus. The left humeral proximal end is well preserved and the distal condyles are thick and rounded. The right proximal end is large and expansive, the distal end has been lost, but its length is estimated to be approximately 22 mm, which is 76% the length of the femur. The radius-ulna is short and thick with slight curvature, termini are extremely expanded, and midsection is slightly constricted. Their length is 13.5 mm, being only 47% the length of the tibia-fibula. The remaining forelimb is incomplete, but on the left side seven small pisiform-shaped carpals are preserved. Only three metacarpals are visible on the right side, all with expanded termini and constricted midsections, and the proximal ends are slightly broader than the distal ends. Digits are fragmentary.

The pelvic girdle is narrow and elongated. In dorsal perspective it is a slightly rounded vertex angle that should exceed 25 mm in length and has a maximum anterior breadth of 13 mm. The ilia are arched and plate-shaped with a length of 22 mm, are fused posteriorly with a 5.5 mm contact, and there is a small element at the posterior end that may represent an ischium.

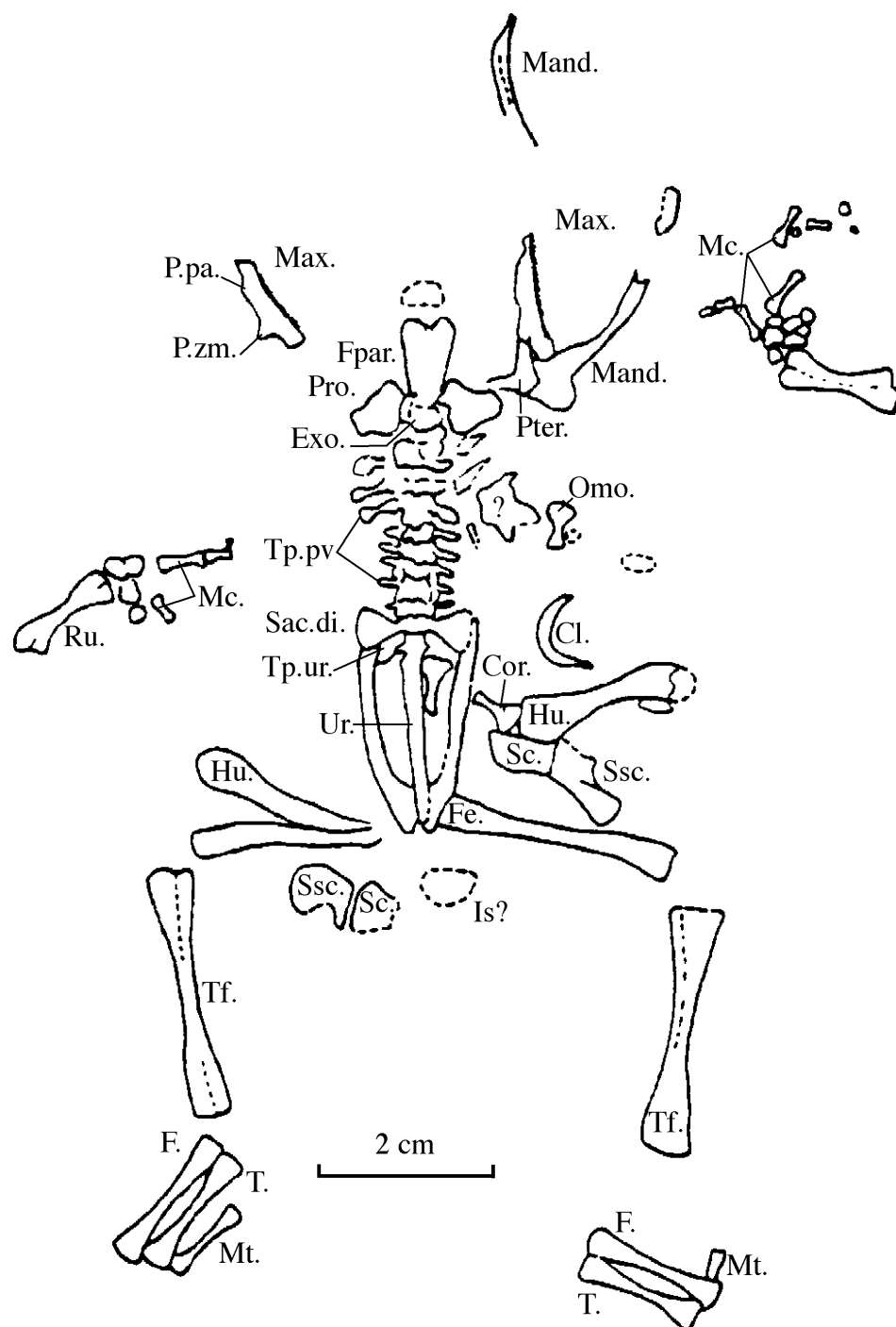


Figure 1. Drawing of *Liobatrachus grabau* gen. et sp. nov. (GMV2126). Cl. clavicle, Cor. coracoid, Exo. exoccipital, F. fibulare, Fe. femur, Fpar. frontoparietal, Hu. humerus, Il. ilium, Is. ischium, Mand. mandible, Max. maxilla, Mc. metacarpal, Mt. metatarsal, Omo. omosternum, P.pa. palatine process of maxilla, Pro. prootic, Pter. pterygoid, P.zm. zygomatic process maxilla, Ru. radius-ulna, Sac.di. sacral diapophyses, Sc. scapula, Ssc. Suprascapula, T. Tibiale, Tf. Tibia-fibula, Tp.pv. Transverse process (diapophysis) of presacral vertebrae, Tp.ur. Transverse process (diapophysis) of urostyle, Ur. urostyle.

The hind limb is relatively elongated with a 29-mm-long weakly sinuous right femur with expanded termini. Tibia and fibula are completely fused with their contact groove being barely discernable, shafts are straight, equivalent in length to the femur, termini are expanded with flattened articular facets, and midshaft is constricted to half the diameter of the termini. Tarsalia are 17 mm in length and include only an elongated tibiale and fibulare, which are 59% the length of the tibia-fibula or approximately 23% of the body length (from rostrum to posterior pelvic girdle). The tibiale and fibulare are consistent in morphology with expanded termini and constricted midshafts, the medial side of the tibiale is slightly shorter than the lateral side of the fibulare, with differential lengths of 15 mm and 17 mm. Their termini are in contact but are not fused. With the exception of a single left and right metatarsal, the remaining metatarsals and phalanges are not preserved.

Comparison and discussion: Over twenty families are currently recognized within the Anura. Lynch (1973) discussed 38 characters used in family taxonomic diagnosis, the most significant of which include: presacral vertebral count, vertebral morphology, presence or absence of ribs, pectoral girdle model, presence or absence of omosternum, quantity of tarsals, presence or absence of dentition, fusion and or loss of cranial elements, and morphology of parasphenoid. Additional relatively significant characters include the size of sacral diapophyses, presence or absence of urostyle diapophyses, length of posterior presacral diapophyses, and superimposition of clavicle on the scapula.

The Beipiao specimen possesses nine presacral procoelous vertebrae that lack ribs, diapophyses on the anterior vertebrae are elongated but posteriorly they are reduced, sacral diapophyses are enlarged and expanded, urostyle diapophyses are present, pectoral girdle is arcuate, maxillae bears a dentition, and two tarsalia are present. With the exception of the nine presacral vertebrae count, the remaining characters are all typical of the Pelobatidae (Lynch, 1973; Duellman and Trueb, 1986). Moreover, this text provisionally assigns the Liaoning specimen to this family following Trueb (1973), who diagnosed the Pelobatidae as possessing eight to nine presacral vertebrae. The only other taxa that possess nine presacral vertebrae are genera within the Leiopelmatidae and Discoglossidae, however, their anterior presacrals possess short ribs and further characters easily distinguish them from the Liaoning specimen.

The Pelobatidae contains over ten genera and one hundred species (including paleontological taxa). The North American Late Jurassic Morrison Fm. at Como Bluff, Wyoming, produces numerous fragmentary anuran specimens, among which are isolated ilia that have been diagnosed as Pelobatidae (Evans et al., 1993). However, these materials cannot be compared to the Chinese specimen due to their fragmentary nature. The nine presacral vertebrae of the Liaoning specimen excludes it from an assignment to any known Late Cretaceous or Cenozoic genera in the family and thus undoubtedly justifies its erection as a new primitive genus and species representing the oldest member of the family.

The torso of *Liaobatrachus* is relatively short, as exemplified by the urostyle exceeding the length of the presacral series. The pelvic girdle is well developed, the hind limb is relatively long (forelimb/hind limb index of .61), tarsalia are slightly elongated with their lengths constituting .59 the length of the tibia-fibula and .23 the total body length, indicating that the species lay in a transitional phase toward completely functional saltation.

It appears that genuine extant anuran characters were not present until the Jurassic, as *Triadobatrachus massinoti* from the Early Triassic of Madagascar is in a transition phase toward the genuine anuran condition. However, to date, the record of Jurassic anurans is extremely restricted, as reviewed by Estes et al. (1973) and Evans (1990). Early Jurassic Anura are only documented from the South American locality of Santa Cruz, Argentina, and the North American locality of Gold Springs, northern Arizona. Middle Jurassic specimens are produced only from the Oxfordshire Group in the United Kingdom. Late Jurassic specimens are more numerous,

represented by Santa Cruz; North American localities in Wyoming, Utah, and Colorado; the Lerida Province of Spain, the Dorset region of England, the Guimarota region of Portugal, and now Liaoning Province, China.

The diversity of Jurassic anurans is low, being restricted to only a few families including the Leiopelmatidae, Prosaliridae, Discoglossidae, Palaeobatrachidae, and Pelobatidae. All of these families are represented by extant species with the exception of the Prosaliridae and Palaeobatrachidae. Many herpetologists recognize these families as relatively primitive, although their phylogenetic relationships are still vague. The vast majority of extant anuran families are absent in the Jurassic.

In conclusion, the Salientia represent a small form of amphibians adapted to terrestrial and shallow water habitats. The group was extremely restricted biogeographically in the Early to Middle Jurassic but in the Late Jurassic attained global distribution. Consequently, the complete disaggregation of the supercontinents could not have occurred prior to the Late Jurassic, and the intervals and differential rates of continental displacement had a significant effect upon later biogeography of the group.

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