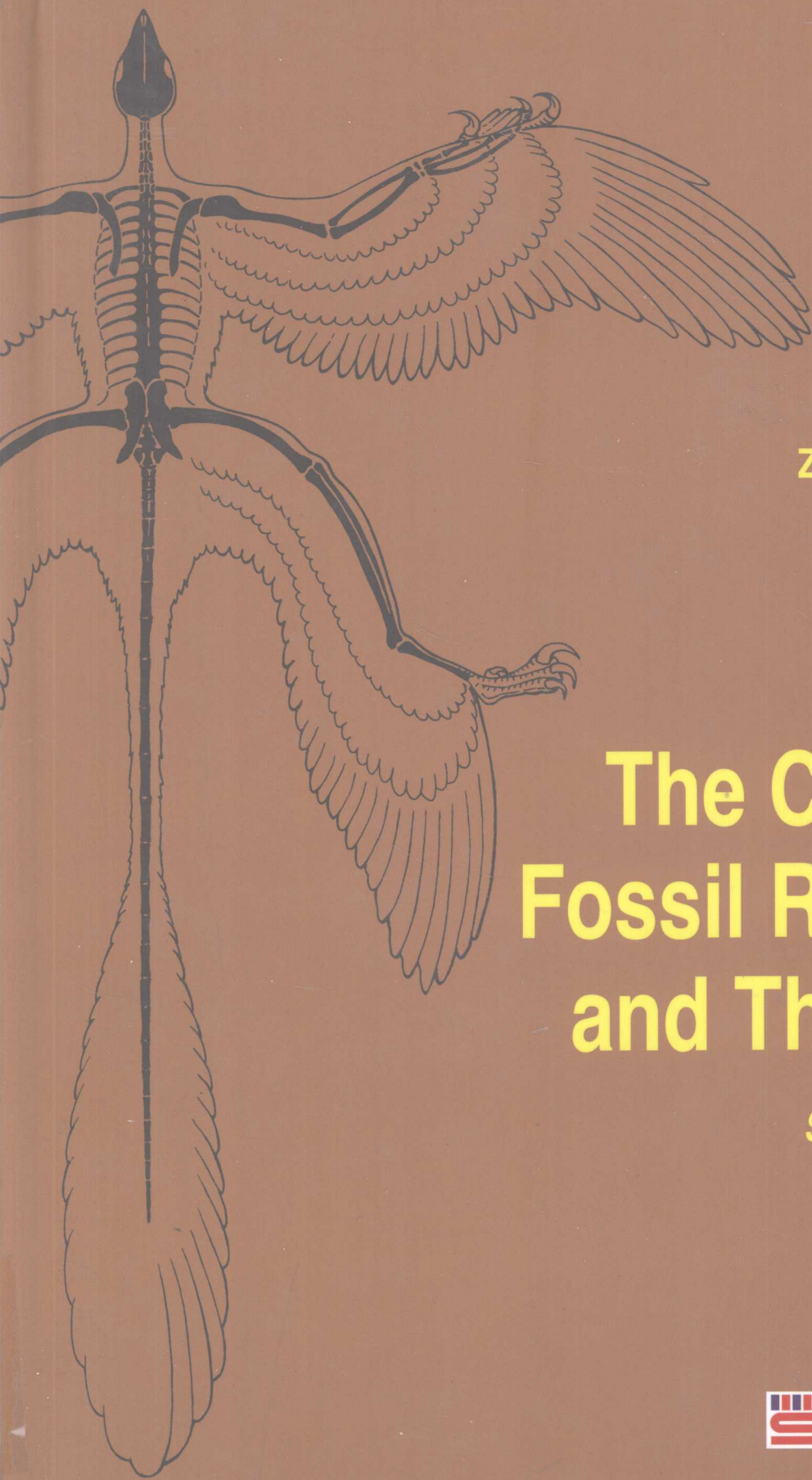




Edited by

LI Jinling
WU Xiaochun
ZHANG Fucheng

The Chinese Fossil Reptiles and Their Kin

Second Edition



Science Press
Beijing

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PREFACE

The first edition of *The Chinese Fossil Reptiles and Their Kins*, which includes the fossil amphibians, reptiles, synapsids, and birds of China, was published in English in 1992. It is a professional book written to introduce the lower vertebrate fossils of China to paleontologists around the world. The book received world-wide attention and was sold out shortly after its appearance because it was well written and well-illustrated with plentiful text figures.

As a result of the many remarkable achievements in the vertebrate paleontology of China during the last 15 years, it is necessary to update *The Chinese Fossil Reptiles and Their Kins*. We hope that the new edition of the book will become a window through which paleontologists will have a broad view of recent research on the fossil lower vertebrates and birds of China.

The whole book was compiled by the specialists whose names are listed in each section. The specialists who worked on the last edition of the book are named as the junior author in each section but they are not responsible for any mistakes the present edition may have.

Illustrations indicated particularly in their captions are from published sources, others either from the last editions or innovation for this edition.

We would like to thank the Chinese Academy of Sciences, the Ministry of Science and Technology of the People's Republic of China, and National Natural Science Foundation of China, for the moral and financial support that made achievement by the authors in the past decades possible.

The editors and authors express their appreciation to Professor Susan E. EVANS for reading and improving the preface, introduction, and manuscripts of amphibians and squamates, Dr. MIAO Desui for reading and improving the preface, and introduction. We are grateful to YANG Mingwan, XU Yong, DING Xiaoqing and HE Li for their assistance with some illustrations.

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INTRODUCTION

Paleontology is one of the oldest scientific disciplines. The study of fossil lower vertebrates and birds in China has taken place for more than 100 years since the first dinosaur skeleton was unearthed in Heilongjiang in 1902. However, in the last 15 years (1992–2006) this traditional discipline has been refreshed in China. During this period, 172 new genera and 219 new species have been described. They have come from strata of the Late Devonian and every period since the Late Paleozoic Permian. The most outstanding achievements of those years were derived from the China–Canada Dinosaur Project and studies of the Jehol Biota of western Liaoning, the Dashankou fauna in Gansu, and the Triassic marine fauna in Guizhou.

The China–Canada Dinosaur Project was one of the largest paleontological expeditions in the world. During the period from 1986 to 1990, a series of field expeditions discovered and collected thousands of tons of vertebrate fossils belonging to all major groups of vertebrates. Many of the studies on these collections have filled gaps in our knowledge of the evolution of major groups of lower tetrapods, provided strong evidence to resolve long standing problems of dinosaur evolution, and deepened our understanding of faunal exchanges between the Asia and North America during the Mesozoic.

The Jehol Biota was discovered as early as the 1920s and was then represented mainly by the conchostracan *Eosestheria*, the insect larva *Ephemeroptera*, and the fish *Lycoptera*. Since 1992, the continuous discovery of new material has greatly enriched the Jehol Biota, and many of the new finds have astonished the world, especially in the paleontological field. The Jehol Biota is Early Cretaceous in age. Its vertebrate members so far known include fishes (lampreys, chondrosteans, amiiforms, and osteoglossomorphs), amphibians (caudates and salientians), turtles, choristoderans, lizards, pterosaurs, dinosaurs (saurischians and ornithischians), birds, and primitive mammals. The discovery of a variety of fossil birds has provided important information with respect to the early evolution of birds, while the discovery of a number of dinosaurs with the imprints of feathers or feather-like filaments has provided the most significant evidence in support of the hypothesis of the dinosaurian origin of birds. The latter has also greatly stimulated the study of the ecology and physiology of theropod dinosaurs as well as the origin of bird flight. The discovery of caudate amphibians has brought us important information on the early history and zoogeography of this amphibian group.

Discovered in the 1990s, the Late Permian Dashankou Fauna of Yumen in Gansu Province, is the earliest known lower tetrapod fauna in China. Its seven genera belong to six families and represent the first occurrences of these groups in China, although anthracosaurs and captorhinomorphs had previously been reported there. The discovery of this fauna completes the sequence of Chinese Permian–Triassic vertebrate faunas, providing significant information for the early evolution and paleozoogeography of temnospondyl amphibians, captorhinomorphs and, especially, therapsids.

The study of Triassic marine reptiles reached a new stage in China towards the end of the twentieth century. In addition to new forms of eosauroptrygians and ichthyosaurs, placodonts, thalattosaurs, marine protosaurs and marine archosaurs were discovered for the first time in China. This has led not only to a perfect correlation, at higher taxonomic levels, between the marine reptilian faunas of the west Tethys and eastern Pacific regions, but has also provided valuable information on the morphology, ontogeny, paleogeography, and

even reproductive patterns of these animals.

In the present edition, the Linnaean system of classification has been retained but relationships among taxa are depicted in as many cladograms as possible. Relationships among the major taxa of Tetrapoda at higher taxonomic levels are shown in figure 1 and relationships among those at lower taxonomic level can be seen in each section. Taxa, of any taxonomic level, are generally not included in the cladograms if their representatives have not yet been found in China.

INTRODUCTION

(The first edition, 1992)

In China, the investigation of reptile fossils commenced at the beginning of this century, almost half a century later than that of mammal. Up to the present, 104 families, consisting of 228 genera and 328 species have been documented and incorporated into this book. The geographical and stratigraphical distribution of all the known fossil localities are shown in the accompanying figures and tables.

The earliest definite records of the occurrence of reptilian fossil in China are the presence of Late Permian dicynodonts and pareiasaurs from Xinjiang Uygur Autonomous Region and the Ordos Region (the 'Big Bend' of the Huanghe River) in North China.

The Early Triassic *Lystrosaurus* fauna is well represented in Xinjiang, where *Lystrosaurus* and *Chasmatosaurus* have been known together with their contemporaries. The Middle Triassic is represented by the assemblage with kannemeyeriids and thecodonts. They occurred both in North China and in Xinjiang. A unique type of reptile, *Lotosaurus*, excavated from an isolated Middle Triassic bone-bed of Badong Formation in Hunan, can hardly be compared confidentially with any reptilian groups known from the Gondwanian sequence.

The earlier Late Triassic fauna is known only from a few of fragmentary specimens from Xinjiang, which afford very little information.

The Lower Lufeng Formation of Yunnan at the boundary of Triassic-Jurassic provides a rich and well represented collection of 'Lufengosaurus Fauna' (= Lufeng Saurischia Fauna). The lower part of the formation, known as the 'Dull Purplish Beds', contains prosauropod *Lufengosaurus* and its relative *Anchisaurus*. The tritylodont *Bienotherium* and a lot of other forms also seemed to have originated from here. Fossil from the upper part of the formation, the 'Dark Red Beds' is dominated by those of small tritylodonts, crocodylomorphs and mammals, besides of dinosaurs. An age of Liassic has recently been suggested for the 'Dark Red Beds'.

Above the Dark Red Beds, occur two Jurassic dinosaur-bearing beds widely over Southwest China: Sichuan and its neighbouring provinces. A primitive sauropod, *Shunosaurus* from the Xiashaximiao Formation, together with carnivorous *Gasosaurus*, stegosaur *Huayangosaurus* and other forms constitute the *Shunosaurus* Fauna of Middle Jurassic age. Dashanpu Quarry at Zigong is the richest fossil site of this age. From the upper member, *Mamenchisaurus* Fauna of Late Jurassic, occurring in the Shangshaximiao Formation is rich in sauropods *Mamenchisaurus* and *Omeisaurus*, carnosaurs *Yangchuanosaurus* and *Szechuanosaurus*, and stegosaur *Toujiangosaurus*.

In the far northwest part of China Jurassic fossiliferous beds in Xinjiang are represented by Wucaiwan Formation and Shishugou Formation successively. The former has yielded fossils of sauropod *Bellusaurus* and advanced tritylodont *Bienotheroides*. It could be correlated with the Xiashaximiao Formation of the Middle Jurassic in Sichuan. The upper formation possesses sauropod *Tienschanosaurus*, carnosaurs and psittacosaur, which is considered as Late Jurassic.

Lower Cretaceous dinosaur-beds spread more widely over the whole country. Psittacosaur-pterosaur assemblage is well known to represent a fauna from the Tugulu Formation in Xinjiang. Quite a number of well preserved flying reptiles, *Dsungaripterus* had been excavated

together with *Psittacosaurus*. Among the assemblage, there are also stegosaur *Wuerhosaurus*, some carnosaurs, coelurosaurs and crocodiles. From the eastern region, *Psittacosaurus* is known from both Shandong and Liaoning provinces. Sauropod *Euhelopus* is an important member of this complex in Shandong.

The Late Cretaceous fauna is well represented by forms from the Wangshi Formation in Shandong, where the hadrosaurs *Tsintaosaurus* and *Shantungosaurus* are the dominance. Besides, hadrosaurs and other elements of this age have been reported from Inner Mongolia, Xinjiang, etc. as well. That from Guangdong Province is featured by an unusual form, *Nan-shiungosaurus*, while its partner *Segnosaurus* existed in Mongolia.

There are records of Cenozoic fossil mostly of modern groups of amphibian, reptile and bird. From Paleocene to Pleistocene, their kins lived with their mammalian contemporaries.

Table 1 A tentative correlation of some Chinese Upper Permian and Triassic formations containing reptile fossils

Northern China (terrestrial deposits)					Southern China (marine deposits)						
Series	Xinjiang	Gansu	North China	Inner Mongolia (Daqingshan)	Xizang	Guizhou			Hubei	Anhui	Guangxi
Upper Triassic					Qulonggongba Fm.						
	Huangshanjie Fm.		Tongchuan Fm.			Falang Fm.	Wayao Mem.	Zhuganpo Mem.			
Middle Triassic						Yangliujing Fm.					
	Karamayi Fm.		Ermaying Fm.			Guanling Fm.	Mem. II	Mem. I	Badong Fm.		
Lower Triassic											
	Shaofanggou Fm.		Heshanggou Fm.						Jialingjiang Fm.	Nanlinghu Fm.	Beisi Fm.
	Jiucaiyuan Fm.										
Upper Permian	Guodikeng Fm.	Sunan Fm.	Shiqianfeng Fm.	Nanbaogou Fm.							
	Wutonggou Fm.										
	Quanzijie Fm.	Xidagou Fm.									
	Hongyanchi Fm.		Upper Shihezi Fm.								
	Lucaogou Fm.										

INSTITUTIONAL ABBREVIATIONS

AGM	Anhui Geological Museum (Anhui Province)
AM	Anhui Museum (Anhui Province)
AMNH	American Museum of Natural History (USA)
ANHM	Amur Natural Historical Museum (Blagoveshchensk, Russia)
BMNH	British Museum (Natural History) (UK)
BNHM	Beijing Natural History Museum (Beijing)
BPM	Beipiao Paleontological Museum (Liaoning Province)
CCMGE	Chernyshev's Central Museum of Geological Exploration (St. Petersburg, Russia)
CDPC	Changzhou Dinosaur Park (Jiangsu Province)
CHM	Chongqing Museum (Chongqing)
CMNH	Chongqing Museum of Natural History (Chongqing)
CNHM	Chicago Natural History Museum (USA)
CNMM	Central National Museum, Manchuria (during Japanese occupation in 1930's-1940's)
CRL	Cenozoic Research Laboratory (Predecessor of IVPP) (Beijing)
CUP	Catholic University of Peking (Beijing)
CUST	Changchun University of Science and Technology (Jilin Province)
DMK	Dingxiao Museum of Keichousaur (Guizhou Province)
DNM	Dalian Natural Museum (Liaoning Province)
GCC	Geological College of Chengdu (Chengdu University of Technology) (Sichuan Province)
GCH	Geological College of Hebei (Shijiazhuang University of Economics) (Hebei Province)
GH	Geological Survey of Hebei (Hebei Province)
GM	Guizhou Museum (Guizhou Province)
GMC	Geological Museum of China (Beijing)
GMH	Geological Museum of Heilongjiang (Heilongjiang Province)
GMN	Geological Museum of Nanjing (Jiangsu Province)
GMPKU	Geological Museum of Peking University (Beijing)
Gmr	Geological Survey of Guizhou (Guizhou Province)
GSLTZP	The Third Geology and Mineral Resources Academy of Gansu (Gansu Province)
HPM	Hezheng Paleozoological Museum (Gansu Province)
HV	Hainan Museum (Hainan Province)
IGCAGS	Institute of Geology, Chinese Academy of Geological Sciences (Beijing)
IMM	Inner Mongolia Museum (Inner Mongolia Autonomous Region)
IVPP	Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (Beijing)
JGMM	Jiangsu Geology and Mineralogy Museum (Jiangsu Province)
JLUM	Jilin University Museum (Jilin Province)
JZMP	Jinzhou Museum of Paleontology (Liaoning Province)
KM	Kunming Museum (Yunnan Province)

LDM	Lufeng Dinosaurs Museum (Yunnan Province)
LH	Long Hao Geologic Paleontological Research Center (Inner Mongolia Autonomous Region)
LHV	Bureau of Land and Resources of Liaoning (Liaoning Province)
LnPM	Liaoning Paleontology Museum (Liaoning Province)
LqPM	Linqu Paleontology Museum (Shandong Province)
NIGP	Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (Jiangsu Province)
NMNS	National Museum of Natural Science (Taiwan Province)
NSMT	National Science Museum of Tokyo (Japan)
NWU	Northwest University (Shaanxi Province)
PIN	Paleontological Institute, Russian Academy of Sciences (Russia)
PKU	Peking University (Beijing)
PMU	Paleontological Museum of Uppsala University (Sweden)
RCPS	Research Center of Palaeontology and Stratigraphy, Jilin University (Jilin Province)
RGSTHP	Regional Geological Surveying Team of Hubei (Hubei Province)
SHM	Shandong Museum (Shandong Province)
SMU	Southern Methodist University (USA)
TMNH	Tianjin Museum of Natural History (Tianjin)
WCRAI	Wuwei Cultural Relic Administrative Institute (Anhui Province)
XMGM	Xinjiang Mineralogy and Geology Museum (Uygur Autonomous Region of Xinjiang)
YFM	Yizhou (Yixian) Fossil Museum (Liaoning Province)
YIGMR	Yichang Institute of Geology and Mineral Resources (Hubei Province)
YX	Yuxi Cultural Relic Administrative Institute (Yunnan Province)
ZDM	Zigong Dinosaurs Museum (Sichuan Province)
ZHM	Zhejiang Museum (Zhejiang Province)
ZMNH	Zhejiang Museum of Natural History (Zhejiang Province)
ZMSI	Zigong Museum of Salt Industry (Sichuan Province)
ZPAL	Palaeobiological Institute, Polish Academy of Sciences (Warsaw, Poland)

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