

Communication

Not peer-reviewed version

Internal Details Corroborate the Occurrence of Flower Bud in the Lower Cretaceous of China

[Weijia Huang](#) and [Xin Wang](#) *

Posted Date: 5 April 2024

doi: 10.20944/preprints202404.0419.v1

Keywords: fossil; Lower Cretaceous; China; angiosperms; flower; bud



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Communication

Internal Details Corroborate the Occurrence of Flower Bud in the Lower Cretaceous of China

WeiJia Huang¹ and Xin Wang^{2,*}

¹ Blue Miracle Museum Science Research Studio, Guangzhou 510000, China

² State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology and CAS Center for Excellence in Life and Palaeoenvironment, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing 210008, China

* Correspondence: xinwang@nigpas.ac.cn

Simple Summary: Flowers are beautiful mainly due to their colorful and conspicuous perianth, which is closely related to successful insect pollination in extant angiosperms. The Early Cretaceous (1.25 million years ago) Yixian Formation in Northeastern China is famous for its great diversity of early angiosperms. However, unlike typical flowers in extant angiosperms, the previously documented fossil flowers are usually “naked”, namely, they do not have typical petals, suggestive of a pollination strategy of early angiosperms different than of the extant angiosperms. However, without fossil evidence, whether there are petals, whether androecium and gynoecium are protected somehow in early flowers are rarely addressed questions. Here we document a flower bud fossil, *Archaeobuda cretaca* sp. nov, from the Yixian Formation. While reinforcing the truthful occurrence of fragile flower bud in the Early Cretaceous, new fossil evidence demonstrates the gynoecium and possible androecium within the flower bud, suggestive of the protection function of petals in *Archaeobuda* as in extant flowers. In addition, petals plays an important role in attracting insect for successful pollination in early angiosperms. Therefore the occurrence of petals in *Archaeobuda cretaca* sp. nov sheds a new light on reproduction of early angiosperms.

Abstract: The Yixian Formation (Lower Cretaceous) of China is famous worldwide for its fossils of early angiosperms, but there is only one record of flower bud hitherto. A previous fossil record of flower bud just showed the appearance and lacked any internal details. Such a lacuna in knowledge of flower buds hinders our understanding of the evolution of flowers. Our new specimen was collected from an outcrop of the Yixian Formation (the Barremian-Aptian, Lower Cretaceous) near Dawangzhangzi, Lingyuan, Liaoning, China. The specimen was observed and photographed using a Sony ILCE-7 digital camera and a Nikon SMZ1500 stereomicroscope, and details were observed using a TESCAN MAIA3 SEM. Our observations document a fossil flower bud, *Archaeobuda cretaca* sp. nov, from the Lower Cretaceous of China. The occurrence of two species of *Archaeobuda* in the Yixian Formation not only confirms the existence of the expected gynoecium (and possible androecium) in a flower bud, but also underscores the occurrence of typical flowers in the Early Cretaceous.

Keywords: fossil; lower cretaceous; China; angiosperms; flower; bud

1. Introduction

Angiosperms are indispensable components of the current ecological background for human beings' origination and evolution. Their origin and early evolution have been foci of botanical controversies for a long time. Fossil evidence from the Yixian Formation plays an important role in improving our understanding on the origin and evolution of angiosperms. In strong contrast to the abundance and diversity of angiosperms in the Yixian Formation (including *Archaeofructus* and other pioneer angiosperms [1–13]), there is only one report of flower bud in the formation [14]. This single

case makes the concerned conclusion more or less tentative, as the public have long been impressed by the lack of flower bud in the geological history. Here we report a flower bud fossil from the Yixian Formation (Lower Cretaceous). In line with the preceding record, new specimen of *Archaeobuda* with internal details re-underscores the occurrence of flower bud in the Yixian Formation. The discovery not only adds to the existing great diversity of angiosperms in the Lower Cretaceous, and sheds new light on the evolution of early flowers.

2. Materials and Methods

Various fossil animals and plants have been documented in the Yixian Formation of Northeastern China [1-3,5-36], and the age of the formation has been a focus of studies for many stratigraphers [37-46]. There is a general consensus over the age of the formation, namely, approximately 125 Ma (Barremian-Aptian, Lower Cretaceous) [47]. The present fossil specimen was collected from the Dawangzhangzi outcrop of the Yixian Formation near Lingyuan, Liaoning, China (Figure 1). The specimen was preserved as a flattened compression embedded in thin-layered siltstone (Figure 2a). The whole specimen was imaged using a Sony ILCE-7 digital camera. Morphological details were imaged using a Nikon SMZ1500 stereomicroscope equipped with a Nikon DS-Fi1 digital camera and a TESCAN MAIA3 scanning electron microscope (SEM) at Nanjing Institute of Geology and Palaeontology, CAS (NIGPAS). All figures are organized using a Photoshop 7.0.

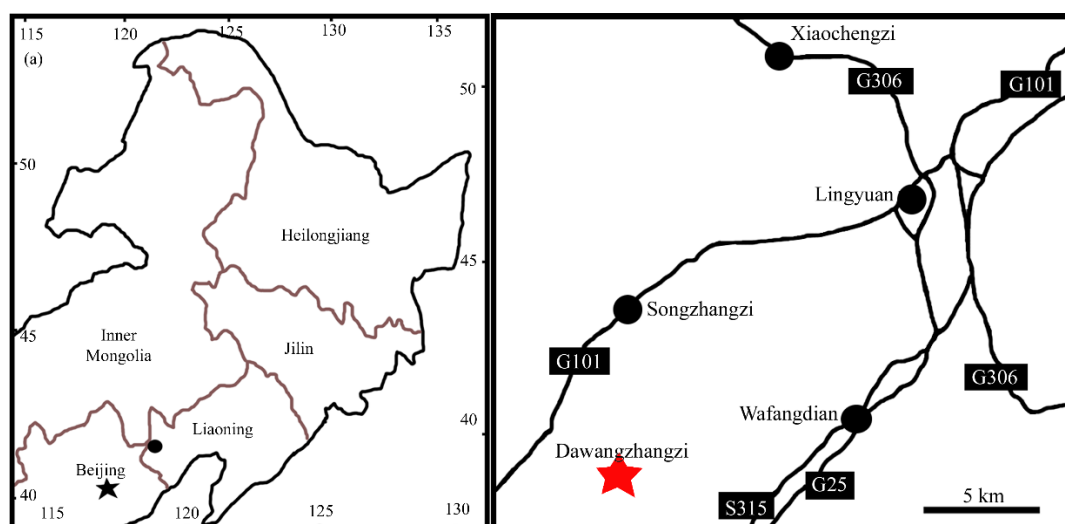


Figure 1. The fossil locality of *Archaeobuda cretaca* sp. nov., Dawangzhangzi, Lingyuan, Liaoning, China. Reproduced from Han et al. [12], with permission and courtesy of Acta Geologica Sinica (English edition). **a.** Fossil locality (black dot) in northeastern China. **b.** Detailed position of fossil locality (red star) in suburb of the City of Lingyuan, Liaoning.

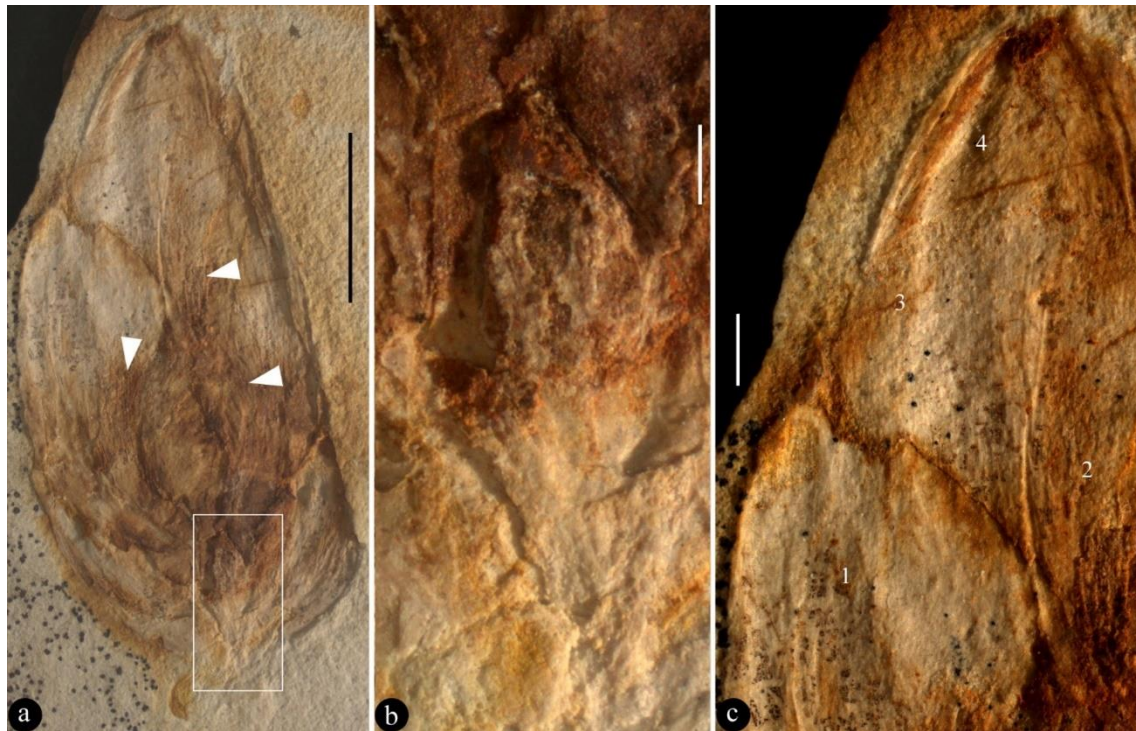


Figure 2. The holotype of *Archaeobuda cretaca* sp. nov. and its details. **a.** The general view of the specimen. Possible androecium is marked with white triangles. Scale bar = 5 mm. **b.** Detailed view of the rectangle in Figure 2a, showing the gynoecium. Scale bar = 0.5 mm. **c.** Detailed view of tip of the bud in Figure 2a, showing different textures on and border between different petals (1-4). Scale bar = 1 mm.

3. Results

Genus *Archaeobuda* Chen and Wang, emended

Emended generic diagnosis: Flower bud long-stalked. Stalk straight, bearing scaly leaves. Scaly leaves long-triangular, spirally arranged along stalk. Bud elongated oval, including two types of foliar appendages. Foliar appendage type I smaller, keeled, round-tipped. Foliar appendage type II bigger, keel free, papery, notched at the tip, overlapping each other, of at least three layers. Gynoecium and possible androecium surrounded by foliar appendage type II.

Type species: *Archaeobuda lingyuanensis* Chen and Wang, 2022 [14].

Species: *Archaeobuda cretaca* sp. nov.

Species diagnosis: (in addition to that of genus), gynoecium bottom-positioned.

Description: The specimen is a compression, 20 mm long and 9 mm wide, preserved as two facing parts embedded in a siltstone (Figure 2a, 3a and S1a-c). Foliar appendages type I are at the base of the bud, smaller than the foliar appendages type II, 2.9-3.5 mm long and 1.1-1.2 mm wide (Figs. 2a, 3a, S1c). Foliar appendages type II are bigger than the foliar appendage type I, 6.4-7 mm long and 3.6-4.6 mm wide, keel-free, papery, notch at the tip not obvious, multiple layers overlapping each other, with longitudinally oriented texture (Figs. 2a, c, 3a, c, S1a-c). Possible trace of androecium is seen, but no pollen grains can be recognized under SEM (Figs. 2a, 3a, S1c). The gynoecium is bottom-position in the flower bud, only 3 mm long and 1.4 mm wide, secluded by an ovary wall that is broken and exposes its internal content (Figs. 2a-b, 3a-b, d, S1c).

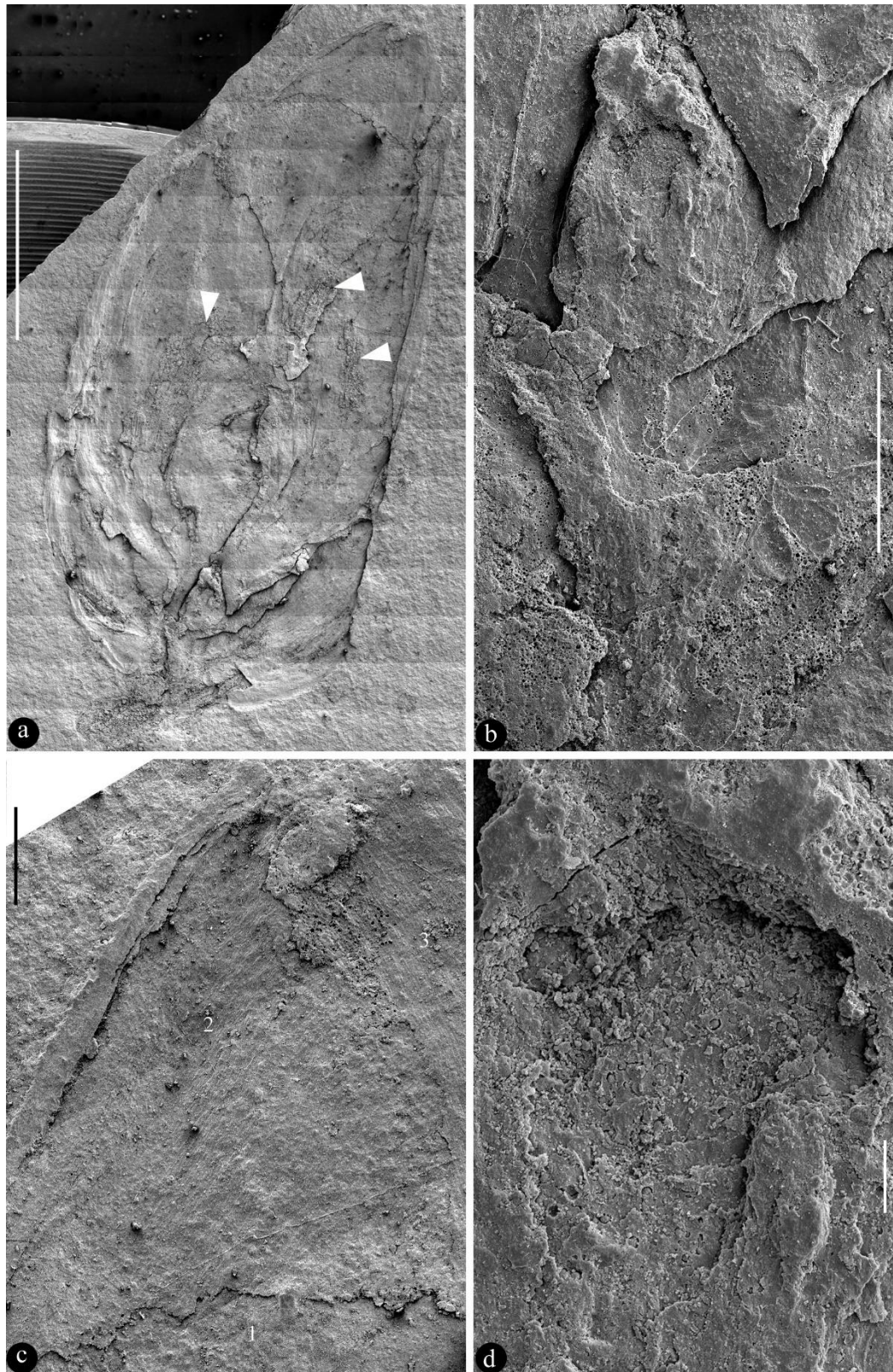


Figure 3. SEM of *Archaeobuda cretaca* sp. nov. **a.** General view of the specimen. Possible androecium is marked with white triangles. Scale bar = 5 mm. **b.** Detailed view of the gynoecium, enlarged from the bottom of Figure 3a. Scale bar = 1 mm. **c.** Detailed view of the tip of the flower bud shown in Figure 3a. Note the textures on different petals (1-3). Scale bar = 0.5 mm. **d.** Detailed view of the gynoecium shown in Figure 3b, shown broken ovary wall and exposed internal details in the gynoecium. Scale bar = 0.1 mm.

Etymology: *cretaca-*, for the Cretaceous, the age of the fossil.

Holotype: BMM79926 (Figs. 2-3, S1).

Type locality: Dawangzhangzi, Lingyuan, Liaoning, China (41°15'N, 119°15'E, Figure 1).

Type horizon and age: the Yixian Formation, equivalent to the Barremian-Aptian, Lower Cretaceous (approximately 125 Ma).

Depository: Blue Miracle Museum Science Research Studio, Guangzhou, China.

Remarks: The general appearance and dimensions of *Archaeobuda cretaca* are comparable to those of the type species *A. lingyuanensis* [14] (Table 1), therefore these features allow us to place our new species in the genus *Archaeobuda*. Different from the type species, *Archaeobuda lingyuanensis* [14], our new species has internal details, gynoecium (and possible androecium), of the flower bud preserved. Someone may be hesitant to accept the interpretation given by Chen and Wang [14], considering they could exclude the possibility for the fossil being certain kind of cones. A cone usually has a cone axis, which is now shown missing in *Archaeobuda cretaca* sp. nov., excluding any possibility *Archaeobuda* being a cone. These additional details confirm the flower bud identity claimed for the type species *Archaeobuda lingyuanensis* by Chen and Wang (2022) [14] and our new species, *Archaeobuda cretaca* sp. nov.

Table 1. Comparison between *Archaeobuda lingyuanensis* and *A. cretaca*.

	<i>Archaeobuda lingyuanensis</i>	<i>Archaeobuda cretaca</i>
Stalk	15 mm long	Not preserved
Length of bud	16 mm	20 mm
Width of bud	9 mm	9 mm
Foliar appendages type I, width	3 mm	1.1-1.2 mm
Foliar appendages type I, length	2.6 mm	2.9-3.5 mm
Foliar appendages type II, width	4.1-6.7 mm	3.6-4.6 mm
Foliar appendages type II, length	4.8-16.8 mm	6.4-18 mm
Androecium	Not visible	Possible
Gynoecium	Not visible	Present

4. Discussions

The great diversity of angiosperms in the Yixian Formation is well known [1–14], including various reproductive organs of angiosperms [1–3,14,48]. Among these fossil, flower buds are a rarity: there is only one previous record, *Archaeobuda lingyuanensis* [14]. Such a sparse record of flower bud not only restricts us from better understanding of flower evolution, but also the credibility of interpreting such precious fossil as a flower bud.

It is well known that previously reported reproductive organs of fossil angiosperms from the Yixian Formation showed little resemblance to extant flowers, as they usually lack a perianth that is frequently seen in extant flowers. Their unusual morphologies make it hard to convince the general public of the truthful occurrence of Cretaceous fossil flowers. To make the situation worse, restricted by the techniques extracting fossil specimens out of sediments, some palaeobotanists even hypothesized that early flowers are of small size. These palaeobotanists forgot that, even there were plant megafossil of flowers, their processing would have destroyed them completely. The combining effects of these two factors heavily inflict our understanding of early flowers and their evolution.

Hitherto there were only two reports of fossil flower buds. One of them is *Florigerminis* [49] recovered from the middle-late Jurassic Jiu-longshan Formation of Inner Mongolia, China, and it is physically connected with branches and a fruit. These connected organs demonstrated a phenomenon rarely seen in the fossil world, flowers in various developmental stages. The other is the congeneric species of *Archaeobuda cretaca*, *A. lingyuanensis*, from exactly the same outcrop of the Yixian Formation. [14]. This fossil was identified as a fossil flower bud based on its general morphology, three overlapping petals (foliar appendages type II), arrangement of the petals and their textures [14]. However, it is unfortunate that the supposed androecium and gynoecium could not be

demonstrated in *Archaeobuda lingyuanensis*. This shortcoming more or less reduces the credibility of the claim made by Chen and Wang [14]. Now with the discovery of *Archaeobuda cretaca*, with information of gynoecium and possible androecium, from the same outcrop, it is more convincing that flower buds did exist in the Early Cretaceous, as the androecium and gynoecium impossible to prove in *Archaeobuda lingyuanensis* are now verified in *Archaeobuda cretaca*.

It is noteworthy that the occurrence of both *Archaeobuda lingyuanensis* and *A. cretaca* in the same outcrop of the Yixian Formation are much bigger than the mesofossil flowers [50]. Formerly, early angiosperms were thought small. Such a conclusion was more or less hinged with the abundant discoveries of mesofossil flowers. However, this may be another six-inch-fishes story in history of science: the technique applied in mesofossil extracting process targets only small (usually <10 mm) parts of plants, while big ones may well have been destroyed during the processing. Now with the discoveries of *Archaeobuda lingyuanensis* and *Archaeobuda cretaca*, this biased view on early flower evolution should be corrected.

Compared to the Jurassic flower bud *Florigerminis* [49], two species of *Archaeobuda* have much bigger flower bud. The flower bud of *Florigerminis* is only 3.8 mm long and 3.3 mm in diameter [49], much smaller than *Archaeobuda*, which is about 20 mm long and 9 mm in diameter. It is noteworthy that the fruit of *Florigerminis* is 11.5 mm long and 7.7 mm in diameter [49], also smaller than the flower bud of *Archaeobuda*. These data indicate that the stark size contrast between *Florigerminis* and *Archaeobuda* is not due to different development stages. This big size of *Archaeobuda* makes their flowers more conspicuous. This fact is apparently conducive to the success of pollination process, especially when it is pollinated by animals.

5. Conclusion

Discoveries of two species of flower bud, *Archaeobuda lingyuanensis* and *A. cretaca*, indicate that at least some of angiosperms in the Early Cretaceous have big flowers, and, together with those atypical ones, typical angiosperms and flowers were already diversified 125 Ma ago.

Supplementary Materials:

Author Contributions: X.W. designed the research. W. J. H. collected the fossil specimen. X.W. and W. J. H. analysed the data and wrote the manuscript. All authors agreed on the manuscript.

Ethics Statement: This research involves no living animal/plant material, no conserved fossil materials.

Funding Information: This research was supported by the National Natural Science Foundation of China (42288201).

Acknowledgments: We thank Mr. Yan Fang for help photography using SEM and Dr. Mike Pole for his help on English.

Conflicts of Interest: The authors claim no conflict of interest.

References

1. Sun, G.; Dilcher, D.L.; Zheng, S.; Zhou, Z. In search of the first flower: a Jurassic angiosperm, *Archaeofructus*, from Northeast China. *Science* **1998**, *282*, 1692-1695.
2. Sun, G.; Ji, Q.; Dilcher, D.L.; Zheng, S.; Nixon, K.C.; Wang, X. Archaeofructaceae, a new basal angiosperm family. *Science* **2002**, *296*, 899-904.
3. Ji, Q.; Li, H.; Bowe, M.; Liu, Y.; Taylor, D.W. Early Cretaceous *Archaeofructus eoflora* sp. nov. with bisexual flowers from Beipiao, Western Liaoning, China. *Acta Geologica Sinica (English edition)* **2004**, *78*, 883-896.
4. Wang, X. *The Dawn Angiosperms*, 2nd ed.; Springer: Cham, Switzerland, 2018; p. 407.
5. Duan, S. The oldest angiosperm ---- a tricarpaceous female reproductive fossil from western Liaoning Province, NE China. *Science in China D* **1998**, *41*, 14-20.
6. Wang, X.; Zheng, X.-T. Reconsiderations on two characters of early angiosperm *Archaeofructus*. *Palaeoworld* **2012**, *21*, 193-201, doi:10.1016/j.palwor.2012.10.002.
7. Wang, X.; Shih, C.; Liu, Z.-J.; Lin, L.; Singh, K.J. Reconstructing the *Callianthus* plant—An early aquatic angiosperm from the Lower Cretaceous of China. *Cretaceous Research* **2021**, *128*, 104983, doi:<https://doi.org/10.1016/j.cretres.2021.104983>.

8. Wang, X.; Zheng, S. The earliest normal flower from Liaoning Province, China. *Journal of Integrative Plant Biology* **2009**, *51*, 800-811, doi:10.1111/j.1744-7909.2009.00838.x.
9. Leng, Q.; Friis, E.M. *Sinocarpus decussatus* gen. et sp. nov., a new angiosperm with basally syncarpous fruits from the Yixian Formation of Northeast China. *Plant Systematics and Evolution* **2003**, *241*, 77-88.
10. Leng, Q.; Friis, E.M. Angiosperm leaves associated with *Sinocarpus* infructescences from the Yixian Formation (Mid-Early Cretaceous) of NE China. *Plant Systematics and Evolution* **2006**, *262*, 173-187.
11. Han, G.; Fu, X.; Liu, Z.-J.; Wang, X. A new angiosperm genus from the Lower Cretaceous Yixian Formation, Western Liaoning, China. *Acta Geologica Sinica (English edition)* **2013**, *87*, 916-925.
12. Han, G.; Liu, Z.; Wang, X. A *Dichocarpum*-like angiosperm from the Early Cretaceous of China. *Acta Geologica Sinica (English edition)* **2017**, *90*, 1-8.
13. Han, G.; Wang, X. A new infructescence of angiosperms from the Early Cretaceous of China. *Acta Geologica Sinica (English edition)* **2020**, *94*, 1711-1713.
14. Chen, L.-J.; Wang, X. A flower bud from the Lower Cretaceous of China. *Biology* **2022**, *11*, 1598, doi:10.3390/biology11111598.
15. Ren, D. Flower-associated Brachycera flies as fossil evidences for Jurassic angiosperm origins. *Science* **1998**, *280*, 85-88.
16. Yao, Y.; Cai, W.; Ren, D. Fossil flower bugs (Heteroptera: Cimicomorpha: Cimicoidea) from the Late Jurassic of Northeast China, including a new family, Vetanthocoridae. *Zootaxa* **2006**, *1360*, 1-40.
17. Liu, Y.; Sinitshenkova, N.D.; Ren, D. A new genus and species of stonefly (Insecta: Plecoptera) from the Yixian Formation, Liaoning Province, China. *Cretaceous Research* **2007**, *28*, 322-326.
18. Ren, D.; Shih, C.; Gao, T.; Yao, Y.; Zhao, Y. *Silent stories*; Science Press: Beijing, 2010; p. 322.
19. Gao, T.; Shih, C.; Rasnitsyn, Alexandr P.; Xu, X.; Wang, S.; Ren, D. New transitional fleas from China highlighting diversity of Early Cretaceous ectoparasitic insects. *Current Biology* **2013**, *23*, 1261-1266, doi:10.1016/j.cub.2013.05.040.
20. Teng, F.; Lü, J.; Wei, X.; Hsiao, Y.; Pittman, M. New material of *Zhenyuanopterus* (Pterosauria) from the Early Cretaceous Yixian Formation of western Liaoning. *Acta Geologica Sinica (English edition)* **2014**, *88*, 1-5.
21. Ding, Q.-H. Research on fossil wood from the Yixian Formation in western Liaoning Province, China. *Acta Geologica Sinica (English edition)* **2000**, *39*, 209-219.
22. Gao, T.; Ren, D. Description of a new fossil *Anthoxyela* species (Hymenoptera, Xyelidae) from Yixian Formation of Northeast China. *Zootaxa* **2008**, 56-62.
23. Huang, D.-Y.; Nel, A. The first Chinese Tarsophlebiidae from the Lower Cretaceous Yixian Formation, with morphological and phylogenetic implications (Odonatoptera: Panodonata). *Cretaceous Research* **2009**, *30*, 429-433.
24. Huang, J.; Ren, D.; Sinitshenkova, N.D.; Shih, C. New genus and species of Hexagenitidae (Insecta: Ephemeroptera) from Yixian Formation, China. *Zootaxa* **2007**, *1629*, 39-50.
25. Lin, Q.-B.; Huang, D.-Y.; Nel, A. A new family of Cavilabiata from the Lower Cretaceous Yixian Formation, China (Odonata: Anisoptera). *Zootaxa* **2007**, *1649*, 59-64.
26. Liu, M.; Lu, W.; Ren, D. A new fossil mordellid (Coleoptera: Tenebrionoidea: Mordellidae) from the Yixian Formation of Western Liaoning Province, China. *Zootaxa* **2007**, *1415*, 49-56.
27. Liu, M.; Ren, D.; Shih, C. A new fossil weevil (Coleoptera, Curculionoidea, Belidae) from the Yixian Formation of western Liaoning, China. *Progress in Natural Science* **2006**, *16*, 885-888.
28. Liu, M.; Zhao, Y.-Y.; Ren, D. Discovery of three new mordellids (Coleoptera, Tenebrionoidea) from the Yixian Formation of western Liaoning, China. *Cretaceous Research* **2008**, *29*, 445-450.
29. Liu, Y.; Ren, D.; Sinitshenkova, N.D.; Shih, C. Three new stoneflies (Insecta: Plecoptera) from the Yixian Formation of Liaoning, China. *Acta Geologica Sinica (English edition)* **2008**, *82*, 249-256.
30. Liu, Y.S.; Ren, D.; Sinitshenkova, N.D.; Shih, C.K. Three new stoneflies (Insecta : Plecoptera) from the Yixian Formation of Liaoning, China. *Acta Geologica Sinica (English edition)* **2008**, *82*, 249-256.
31. Lü, J. A new boreopterid pterodactyloid pterosaur from the Early Cretaceous Yixian Formation of Liaoning Province, Northeastern China. *Acta Geologica Sinica (English edition)* **2010**, *84*, 241-246.
32. Lü, J.; Kobayashi, Y.; Lee, Y.-N.; Ji, Q. A new *Psittacosaurus* (Dinosauria: Ceratopsia) specimen from the Yixian Formation of western Liaoning, China: the first pathological psittacosaurid. *Cretaceous Research* **2007**, *28*, 272-276.
33. Wang, X.; Kellner, A.W.A.; Zhou, Z.; de Almeida Campos, D. A new pterosaur (Ctenochasmatidae, Archaeopterodactyloidea) from the Lower Cretaceous Yixian Formation of China. *Cretaceous Research* **2007**, *28*, 245-260.
34. Wang, X.; Ren, D.; Wang, Y. First discovery of angiospermous pollen from Yixian Formation. *Acta Geologica Sinica (English edition)* **2000**, *74*, 265-272.
35. Zhang, H.; Rasnitsyn, A.P.; Wang, D.; Zhang, Y. Some hatchet wasps (Hymenoptera, Evaniidae) from the Yixian Formation of western Liaoning, China. *Cretaceous Research* **2007**, *28*, 310-316.

36. Zheng, S.; Li, N.; Li, Y.; Zhang, W.; Bian, X. A new genus of fossil cycads *Yixianophyllum* gen. nov. from the Late Jurassic Yixian Formation, Western Liaoning, China. *Acta Geologica Sinica (English edition)* **2005**, *79*, 582-592.
37. Ding, Q.-H.; Zhang, L.-D.; Guo, S.-Z.; Zhang, C.-J.; Peng, Y.-D.; Jia, B.; Chen, S.-W.; Xing, D.-H. The stratigraphic sequence and fossil-bearing horizon of the Yixian Formation in western Liaoning, China. *Geology and Resources* **2001**, *10*, 193-198.
38. Li, J.; Batten, D.J. Palynological evidence of an Early Cretaceous age for the Yixian Formation at Sihetun, western Liaoning, China. *Cretaceous Research* **2007**, *28*, 333-338.
39. Li, Y.; Sha, J.; Wang, Q.; Chen, S. Lacustrine tempestite litho- and biofacies in the Lower Cretaceous Yixian Formation, Beipiao, western Liaoning, northeast China. *Cretaceous Research* **2007**, *28*, 194-198.
40. Peng, Y.-D.; Zhang, L.-D.; Chen, W.; Zhang, C.-J.; Guo, S.-Z.; Xing, D.-H.; Jia, B.; Chen, S.-W.; Ding, Q.-H. $^{40}\text{Ar}/^{39}\text{Ar}$ and K-Ar dating of the Yixian Formation volcanic rocks, western Liaoning province, China. *Geochimica* **2003**, *32*, 427-435.
41. Swisher, C.C.; Wang, Y.; Wang, X.; Xu, X.; Wang, Y. $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the lower Yixian Fm, Liaoning Province, northeastern China. *Chinese Science Bulletin* **1998**, *43*, 125.
42. Wang, W.; Zhang, H.; Zhang, L.; Zheng, S.; Yang, F.; Li, Z.; Zheng, Y.; Ding, Q. *Standard sections of Tuchengzi stage and Yixian stage and their stratigraphy, palaeontology and tectonic-volcanic actions*; Geological Publishing House: Beijing, 2004; p. 514.
43. Wang, W.-L.; Zhang, L.-J.; Zheng, S.-L.; Ren, D.; Zheng, Y.-J.; Ding, Q.-H.; Zhang, H.; Li, Z.-T.; Yang, F.-L. The age of the Yixianian stage and the boundary of Jurassic-Cretaceous, --- the establishment and study of stratotype of the Yixianian stage. *Geological Review* **2005**, *51*, 234-242.
44. Xing, D.-H.; Sun, C.-L.; Sun, Y.-W.; Zhang, L.-D.; Peng, Y.-D.; Chen, S.-W. New knowledge on Yixian Formation. *Acta Geoscientica Sinica* **2005**, *26*, 25-30.
45. Zhang, L.; Gong, E.; Xu, D.; Liu, X.; Li, J. Sedimentary facies of the Yixian Formation of Lower Cretaceous in Sihetun Basin of Beipiao, Liaoning Province. *Journal of Palaeogeography* **2005**, *7*, 70-78.
46. Zhang, L.-D.; Jin, C.-Z.; Guo, S.-Z.; Zhang, C.-J.; Peng, Y.-D.; Chen, S.-W.; Xing, D.-H.; Ding, Q.-H.; Zheng, Y.-J. The precious fossil-bearing beds of Yixian Formation in Beipiao-Yixian area: their ages and correlation. *Geology and Resources* **2004**, *13*, 193-221.
47. Dilcher, D.L.; Sun, G.; Ji, Q.; Li, H. An early infructescence *Hyracantha decussata* (comb. nov.) from the Yixian Formation in northeastern China. *Proceedings of National Academy of Sciences USA* **2007**, *104*, 9370-9374, doi:10.1073/pnas.0703497104.
48. Wang, X. A novel Early Cretaceous flower and its implications on flower derivation. *Biology* **2022**, *11*, 1036.
49. Cui, D.-F.; Hou, Y.; Yin, P.; Wang, X. A Jurassic flower bud from China. *Geological Society, London, Special Publications* **2022**, *521*, 81-93.
50. Friis, E.M.; Crane, P.R.; Pedersen, K.R. *The early flowers and angiosperm evolution*; Cambridge University Press: Cambridge, 2011; p. 596.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.