

A Whole-Plant Monocot from the Early Cretaceous

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Abstract

The Yixian Formation (the Lower Cretaceous) of China is world famous for its fossils of early angiosperms. Although these diverse angiosperms demonstrate an unexpectedly great diversity, few are preserved as whole plants (not mention of monocots), making our understanding of them incomplete. Here, we report a fossil angiosperm, *Sinoherba ningchenensis* gen. et sp. nov (Sinoherbaceae fam. nov.), from the Yixian Formation of China; this fossil has a physically connected underground stem with fibrous rootlets, a stem with branches and nodes, leaves with parallel-reticulate veins, and a panicle of female flowers with an ovary surrounded by perianth. Morphological and phylogenetic analyses revealed that *Sinoherba* is an herbaceous monocot taxon. This newly discovered fossil underscores the great diversity of angiosperms in the Lower Cretaceous Yixian Formation.

Keywords: flower, fossil, Lower Cretaceous, China, angiosperms, herbaceous monocot.

Although angiosperms constitute the most diversified plant group in the current world¹, the origin, evolution and systematics of angiosperms are little understood or misunderstood. Early angiosperms including the famous *Archaeofructus*¹⁻⁴ have been reported from the Yixian Formation of northeastern China, but few of them are preserved as whole plants. Such fragmentary information hinders our full understanding of early angiosperms. To improve our understanding of early angiosperms, here, we report a new fossil plant, *Sinoherba ningchengensis* gen. et sp. nov. (Sinoherbaceae fam. nov.), from the Yixian Formation (the Early Cretaceous, 125 Ma). This fossil has a physically connected underground stem with nodes and fibrous rootlets; a stem with nodes, leaves and branches at the nodes; leaves with parallel-reticulate veins; a panicle arising from the axils of the leaves; and female flowers with an ovary surrounded by perianth. Morphological and phylogenetic analyses revealed that *Sinoherba* is an herbaceous monocot. Furthermore, *Sinoherba* demonstrates a novel character assemblage that helps elucidate the derivation of both gynoecea and growth habits of early angiosperms, underscores the great diversity of angiosperms in the Lower Cretaceous Yixian Formation, and suggests an earlier-than-assumed origin of angiosperms.

The Yixian Formation of China is well known for the Jehel Biota as well as various fossil animals⁵⁻¹² and plants¹³⁻¹⁷. Among the plants are Bryophyta, Lycopodiales, Equisetales, Filicales, Pteridospermae, Cycadales, Bennettitales, Ginkgoales, Czekanowskiales, Coniferales, and Angiospermae¹³⁻¹⁷. A general consensus exists with respect to the age of the Yixian Formation, namely, approximately 125 Ma (the Barremian-Aptian, Lower Cretaceous)¹⁹. The new fossil plant was collected from an outcrop of the Yixian Formation in Dashuangmiao, Ningcheng, Inner Mongolia, China (Fig. 1). The specimen was preserved as a compression/impression in thin-layered siltstone, and embedded coalified residue was present. The specimen is 26 cm long and 5 cm wide; it is preserved on a slightly yellowish grey siltstone slab approximately 25 cm × 38 cm (Fig. 2). The specimen was imaged using a Nikon D200 digital camera and a Nikon SMZ1500 stereomicroscope equipped with a Nikon DS-Fi1 digital camera. The distal portion of the plant was observed using a Leo 1530 VP scanning electron microscope (SEM) at Nanjing Institute of Geology and Palaeontology, CAS (NIGPAS). Sketches of the images were drawn using Photoshop 4.0 software.

Angiospermae

Monocotyledoneae

Family: Sinoherbaceae fam. nov.

Genus: *Sinoherba* gen. nov.

Type species: *Sinoherba ningchengensis* sp. nov.

Family and generic diagnosis: Herb, approximately 26 cm tall, with an underground stem. Nodes on the underground stem with lateral roots. Rootlets fibrous. Stem straight, with obvious nodes, with branches on the upper nodes. Leaves attached to the nodes in whorls, strap-like, with two orders of parallel veins and sparse meshes. Panicle arising from the axil of a leaf. Flowers dense on rachis, probably dioecious, pistil surrounded by 2–3 whorls of perianth. Ovary with a short distal style, partially

separated in the distal half by a septum. Ovule basal, on the bottom of the ovary. Fruits ovate.

Etymology: *Sino-* Latin word for China, *-herba* from Latin word for herbaceous plant.

Species: *Sinoherba ningchengensis* sp. nov.

Specific diagnosis: the same as that of the family and genus.

Description: Whole plant including the roots, stem, leaves, and flowers, 258 mm long and 46 mm wide (Figs. 2–4). The underground stem is 3.4 mm in diameter and 39 mm in length, with several nodes (Fig. 3a). Fibrous roots are borne on the apex and nodes of underground stem, roots with 2–3 orders of fibrous rootlets (Figs. 3a, b). The stem is approximately 5 mm in diameter at the bottom, tapering to 1.4 mm distally, with evident and slightly swollen nodes (Figs. 2, 3c-e). The length of internodes varies from 7 to 27 mm (Figs. 2, 3c). Lateral branches/inflorescences and leaves are inserted on the nodes along the stem (Figs. 2, 3c-e, 4e). Younger lateral branches are in the axils of leaves (Figs. 2, 3e). The leaves are more concentrated on the basal half of the plant and are fully absent on two basal-most nodes of the stem (Figs. 2, 3c, f, g, 4e). A leafless node has leaf scars (Fig. 3d). The leaves are strap-shaped, up to 3.6 mm wide and 39 mm long, base contracted into a petiole (Fig. 3f) clasping the stem (Fig. 3g), apex acute to obtuse (Fig. 3h). The leaf veins are mostly parallel, with two orders of veins and elongated sparse meshes (Figs. 3f, i). The plant is mature, with two panicles (Figs. 4a, e). One of inflorescences arises from the apical node of the stem, the inflorescence has many young flowers, approximately 5 cm in length, with a bract at the base of the scape, mostly concentrated in the distal portion of the plant (Figs. 4a, b). The bract of inflorescence is oblong-lanceolate, apex obtuse (Fig. 4c). The flowers are terminal, alternately arranged along the peduncle, with a superior ovary, 0.2 mm wide and 0.2 mm long, surrounded by perianths (foliar parts) (Figs. 2, 4a, b). Another inflorescence, whose scape arises in the axil of a leaf on the stem, approximately 3.5 cm in length (Fig. 4a). The inflorescence is approximately 3 cm long, with several flowers/fruits (Fig. 4e). The flowers (fruits) are densely arranged along the peduncle and have 2–3 layers of perianth, 6 mm long and 5 mm wide, pedicel short, approximately 1 mm long (Figs. 4e, f). No male parts are recognized. The gynoecium includes a conical ovary and a distal style and is surrounded by perianth (Figs. 4f-h). The ovary is unilocular proximally but bilocular distally, with a wall approximately 67 μm thick and a basal ovule (Figs. 4d, g, h). The style is stout, cylindrical, up to 372 μm in length and 155 μm in diameter (Fig. 4h). The ovule is basal, approximately 670–1000 μm wide and 460–590 μm high (Fig. 4g, h, 6c-d).

Etymology: *ningcheng-*, for Ningcheng City, Inner Mongolia, the fossil locality.

Holotype: LJNG0002 a & b (Fig. 2).

Type locality: Liujianangou, Dashuangmiao Town, Ningcheng, Inner Mongolia, China (41°30.3792'N, 118°51.2465'E, Fig. 1).

Stratigraphic horizon: the Yixian Formation, equivalent to the Barremian-Aptian, Lower Cretaceous (125 Ma).

Depository: The Orchid Conservation & Research Center of Shenzhen, China (NOCC).

The small size and maturity (suggested by the presence of flowers) of *Sinoherba* indicate that it is an herbaceous plant. To the best of our knowledge, herbaceous growth habit among living seed plants is restricted to angiosperms. Therefore, the herbaceous growth habit of *Sinoherba per se* suggests that this plant is likely an angiosperm¹⁸, a conclusion supported by other features of *Sinoherba*.

Sinoherba has a panicle subtended by an inflorescence bract, and the flower is composed of a pedicel, perianths and a gynoecium. Importantly, via their enclosed ovule before pollination, angiosperms are easily distinguished from gymnosperms; enclosed ovules before pollination have never been reported in gymnosperms^{19,20}. As seen in Figs. 4d, f–h and 6c–d, the basal ovule is fully enclosed by an ovary, the latter of which is completely sealed at the tip by a short style and is partially bilocular distally (Figs. 4g, h). These features are characteristic of angiosperms. As such, the angiospermous affinity of *Sinoherba* suggested above is confirmed.

The leaves of *Sinoherba* are arranged at its nodes, and the leaf petioles clasp the stem (Figs. 2, 3c–i); the leaves are not spirally arranged as might be expected according to angiosperm evolution theories²¹. Spiral phyllotaxy was formerly assumed to be ancestral in angiosperms²¹, and unfortunately, this belief is still pervasive among botanists. However, the phyllotaxy of *Sinoherba* apparently contradicts this belief. *Sinoherba* presents leaf characteristics that suggest a monocot affinity. The leaves of *Sinoherba* are oblong-lanceolate and with reticulate veins. The veins are of two orders: the first-order parallel veins converge at the apex, and the second-order veins join the first-order ones (Figs. 3f, h, i). The venation of *Sinoherba* is approximately parallel, a venation rarely seen in eudicots. The underground stem with fibrous rootlets (Fig. 3a) excludes a possible Eudicot affinity for *Sinoherba*, as this type of stem morphology is frequently seen in monocots but rarely seen in eudicots²². Such a character assemblage and herbaceous habit suggest that *Sinoherba* is a monocot.

Sinoherba is probably an helobious plant. An herbaceous nature and roots borne on the basal nodes of underground stem suggest an helobious habitat. The absence of leaves and the presence of leaf scars on the basal nodes of the stem in *Sinoherba* (Figs. 3c, d) suggest that the leaves must have fallen off before fossilization. *Sinoherba* has two types of inflorescences: one is a developing panicle, and the other appears to be an infructescence that probably formed during a different flowering season. In contrast to the presence of leaves on the nodes discussed above, this phenomenon suggests that *Sinoherba* is likely a perennial and deciduous herb that can adapt to environment changes (suggested by leaf falling). Similar character assemblage has been reported for various monocot families, e.g., the Helobiae²³.

To decipher the origin, evolution and systematics of angiosperms correctly and confidently, all hypotheses must be based on fossil evidence. Various fossils of early angiosperms from the Yixian Formation, including those of *Archaeofructus*^{1–4} and *Sinocarpus*^{24,25}, have shed important light on these issues, but few of those fossils are of whole plants. The fossil of *Sinoherba* is unique because it is an herbaceous whole plant, including the roots, stem, leaves, and inflorescences. Phylogenetic analyses of the morphological characters as well as the combination of characters and molecular

data of both extant plants and *Sinoherba* demonstrate that *Sinoherba* is a monocot taxon²⁷ (Figs. 5, S1, S2).

When all the morphological characters of *Sinoherba* are evaluated in a phylogenetic context, *Sinoherba* nests in the angiosperm clade. The angiosperm clade is divided into three subclades: *Archaeofructus*, monocots and eudicots. *Archaeofructus* is a basal clade and is the sister of the monocots and eudicots. The Amborellaceae is the most basal subclade among the eudicots, while the Nymphaeaceae is the most basal subclade among monocots. *Sinoherba* is a monocot taxon and is the sister of the Najadaceae, an aquatic plant family (Fig. S1). Phylogenetic relationships were reconstructed using a combination of morphological characters and plastid DNA regions. The phylogenetic relationships revealed in this analysis (Fig. 5, Fig. S2) are similar to those revealed via morphologic characters alone. All analyses consistently placed *Sinoherba* among the monocots and indicated that it represents a sister of the extant Araceae and Helobiae families (Najadaceae, Alismataceae and Hydrocharitaceae). We hope future studies can test whether *Sinoherba* stands for the basalmost monocot. The characters unique to the Sinoherbaceae are illustrated in reconstruction of *S. ningchengensis* (Fig. 6).

The occurrence of basal ovule in *S. ningchengensis* is unexpected for classical angiosperm evolution. However, similar way of gynoecium forming is commonly seen in angiosperm and is recently termed as mixomery²⁶. Apparently, this new findings in extant as well as fossil angiosperms deserve attention in future study of angiosperm evolution.

The discovery of *S. ningchengensis* and the phylogenetic and morphological analyses refute the Early Cretaceous origin of monocots. Instead, our results favour a more ancient origin of angiosperms.

References and Notes

- 1 Sun, G., Dilcher, D. L., Zheng, S. & Zhou, Z. In search of the first flower: a Jurassic angiosperm, *Archaeofructus*, from Northeast China. *Science* **282**, 1692-1695, (1998).
- 2 Sun, G. *et al.* *Archaeofructaceae*, a new basal angiosperm family. *Science* **296**, 899-904, (2002).
- 3 Ji, Q., Li, H., Bower, M., Liu, Y. & Taylor, D. W. Early Cretaceous *Archaeofructus eoflora* sp. nov. with bisexual flowers from Beipiao, Western Liaoning, China. *Acta Geologica Sinica* **78**, 883-896, (2004).
- 4 Wang, X. & Zheng, X.-T. Reconsiderations on two characters of early angiosperm *Archaeofructus*. *Palaeoworld* **21**, 193-201, (2012).
- 5 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)* **88**, 1-5, (2014).
- 6 Wang, W. *et al.* Mesozoic stratigraphy and paleontology in western Liaoning. Geological Publisher, Beijing, 1989.
- 7 Wang, W.-L. *et al.* The age of the Yixianian stage and the boundary of Jurassic-Cretaceous, --- the establishment and study of stratotype of the

- Yixianian stage. *Geological Review* **51**, 234-242, (2005).
- 8 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* **28**, 322-326, (2007).
- 9 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* **1360**, 1-40, (2006).
- 10 Ren, D. Flower-associated Brachycera flies as fossil evidences for Jurassic angiosperm origins. *Science* **280**, 85-88, (1998).
- 11 Ren, D., Shih, C., Gao, T., Yao, Y. & Zhao, Y. Silent stories. Science Press, Beijing, 2010.
- 12 Gao, T. *et al.* New transitional fleas from China highlighting diversity of Early Cretaceous ectoparasitic insects. *Current Biology* **23**, 1261-1266, (2013).
- 13 Wu, S.-Q. A preliminary study of the Jehol flora from the western Liaoning. *Palaeoworld* **11**, 7-57, (1999).
- 14 Sun, G., Zheng, S., Dilcher, D., Wang, Y. & Mei, S. Early angiosperms and their associated plants from Western Liaoning, China. Shanghai Technology & Education Press, Shanghai, 2001.
- 15 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* **79**, 582-592, (2005).
- 16 Dong, C., Yang, X. & Zhou, Z. in *Daohugou Biota* (ed Diying Huang) 252-302 (Shanghai Science and Technology, 2016).
- 17 Li, G. & Luo, Z. X. A Cretaceous symmetrodont therian with some monotreme-like postcranial features. *Nature* **439**, 195-200, (2006).
- 18 Friis, E. M., Crane, P. R. & Pedersen, K. R. The early flowers and angiosperm evolution. Cambridge University Press, Cambridge, 2011.
- 19 Tomlinson, P. B. & Takaso, T. Seed cone structure in conifers in relation to development and pollination: a biological approach. *Canadian Journal of Botany* **80**, 1250-1273, (2002).
- 20 Wang, X. The dawn angiosperms. Springer, Heidelberg, 2018.
- 21 Cronquist, A. The evolution and classification of flowering plants. New York Botanical Garden, Bronx, 1988.
- 22 Judd, W. S., Campbell, S. C., Kellogg, E. A. & Stevens, P. F. Plant systematics: a phylogenetic approach. Sinauer Associate Inc., Sunderland, MA, 1999.
- 23 Sun, X. in *Flora Reipublicae POPULARIS SINICAE* Vol. 8 32-190 (1992).
- 24 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* **241**, 77-88, (2003).
- 25 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* **262**, 173-187, (2006).
- 26 Sokoloff, D. D., Nuraliev, M. S., Oskolski, A. A. & Remizowa, M. V.

- Gynoecium evolution in Angiosperms: Monomery, pseudomonomery, and mixomery. *Moscow University Biological Sciences Bulletin* **72**, 97-108, (2017).
27. To determine the phylogenetic position of *Sinoherba*, we sampled 169 angiosperm taxa. A morphological matrix was constructed *de novo* (Table S1); the matrix integrated the majority of the morphological features coded (Table S2) by Moreau *et al.*²⁸. For a broad phylogenetic analysis, a total of 141 taxa were included in the analysis of the data set comprising four plastid DNA (*rbcL*, *matK*, *trnL-F* and *psbA-trnH*) sequences and one nuclear (ITS) sequence (The GenBank accession numbers are listed in Table S3). The DNA sequences were aligned with MEGA 5.05²⁹ using the Muscle model³⁰ and manually adjusted to account for obvious or missing inserts. We translated the basic DNA sequence groups A, T, G, and C into 1, 2, 3, and 4, respectively, and subsequently combined the DNA sequences and score information of the morphological characteristics. The phylogenetic analyses were carried out using the maximum parsimony (MP) method. The MP analysis was carried out using PAUP 4.0b10³¹.
 28. J.-D. Moreau *et al.* *Verneda hermaphroditica* gen. & sp. nov.: A new flower head from the early Late Cretaceous (middle Cenomanian) of southeastern France. *Taxon* **65**(4): 823–838 (2016).
 29. K. Tamura *et al.* MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and Maximum Parsimony methods. *Molecular Biology and Evolution* **28** (10): 2731 (2011).
 30. R. C. Edgar. Muscle: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Research* **32** (5), 1792–1797(2004).
 31. D. L. Swofford. *PAUP**. *Phylogenetic analysis using parsimony (*and other methods)*, v. 4.0 beta 10 (Sinauer, Sunderland, 2003).
 32. We thank Ms. Chunzhao Wang for her assistance with the SEM. This research was supported by the National Natural Science Foundation of China (41688103, 91514302); the Chinese Academy of Sciences (Grant No. XDPB05) via a grant awarded to X. W.; the State Forestry Administration of China (No. 2005–122); the Science and Technology Project of Guangdong (No. 2011B060400011); and the Special Funds for Environmental Projects of Shenzhen (No. 2013-02), which was awarded to Z.-J. L.

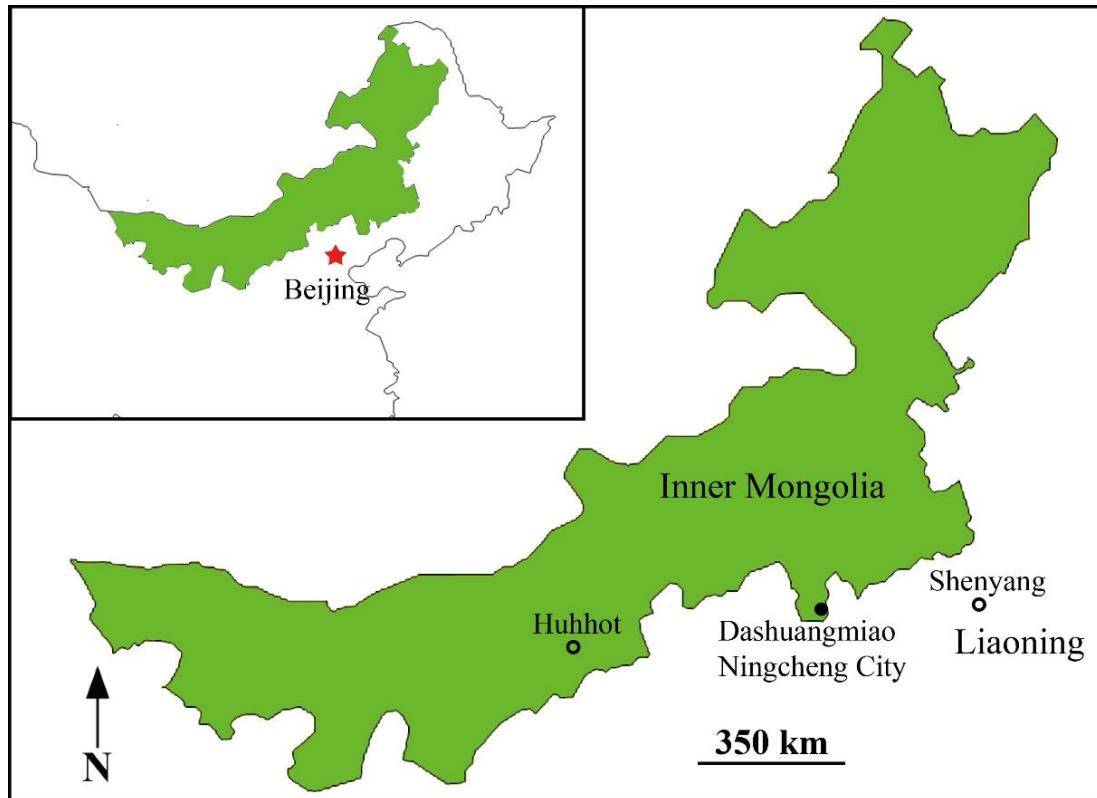


Figure 1. Fossil locations. The map shows the Dashuangmiao locality in Ningcheng of Inner Mongolia from where the fossil *Sinoherba ningchengensis* gen. et sp. nov. was collected. The inset map shows the location of Inner Mongolia in northeastern China (the asterisk indicates Beijing).

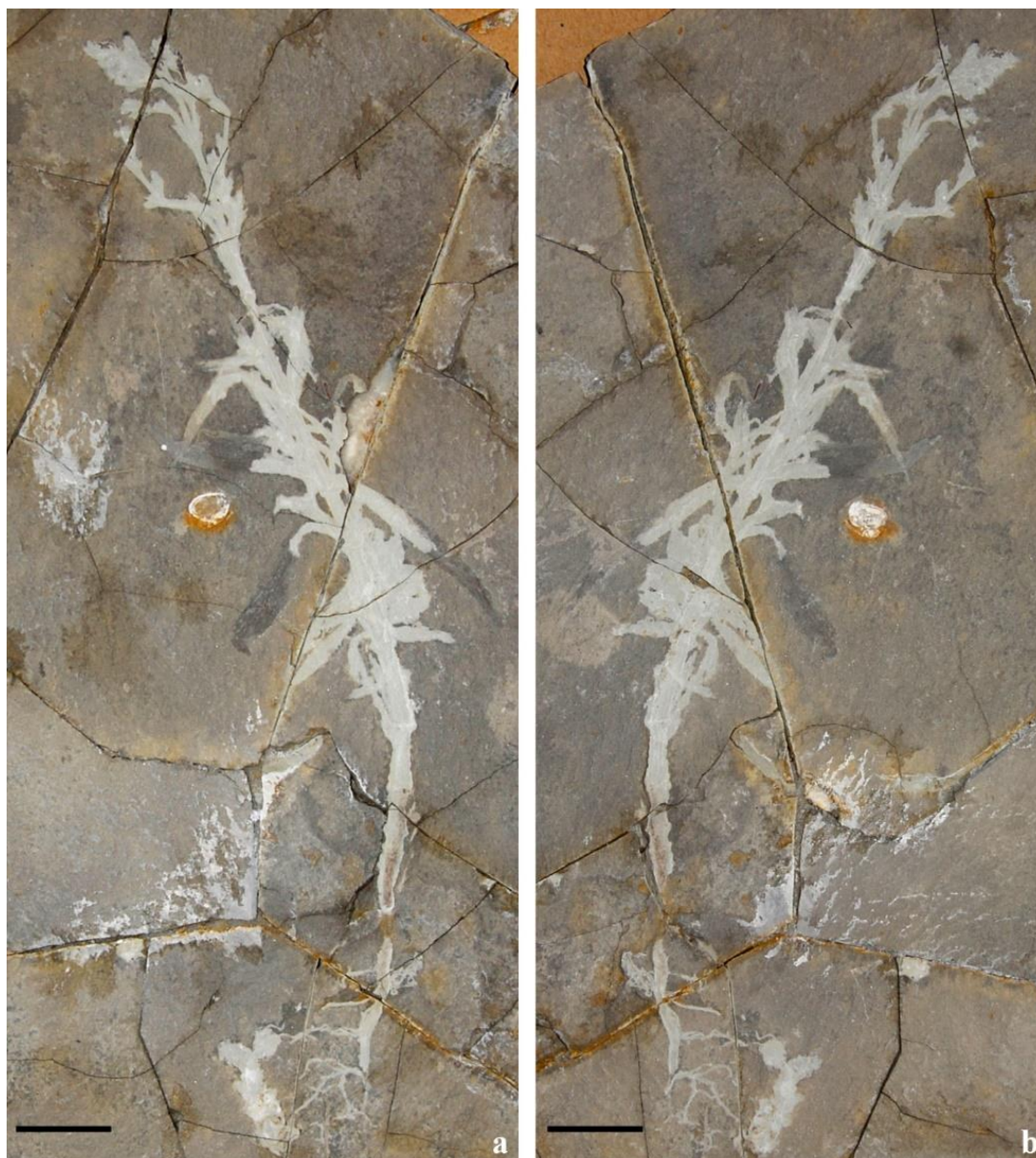


Figure 2. General view of the holotype of *Sinoherba* gen. nov. The whole plant includes the rootlets, stem, leaves and inflorescences. Bar = 2 cm.

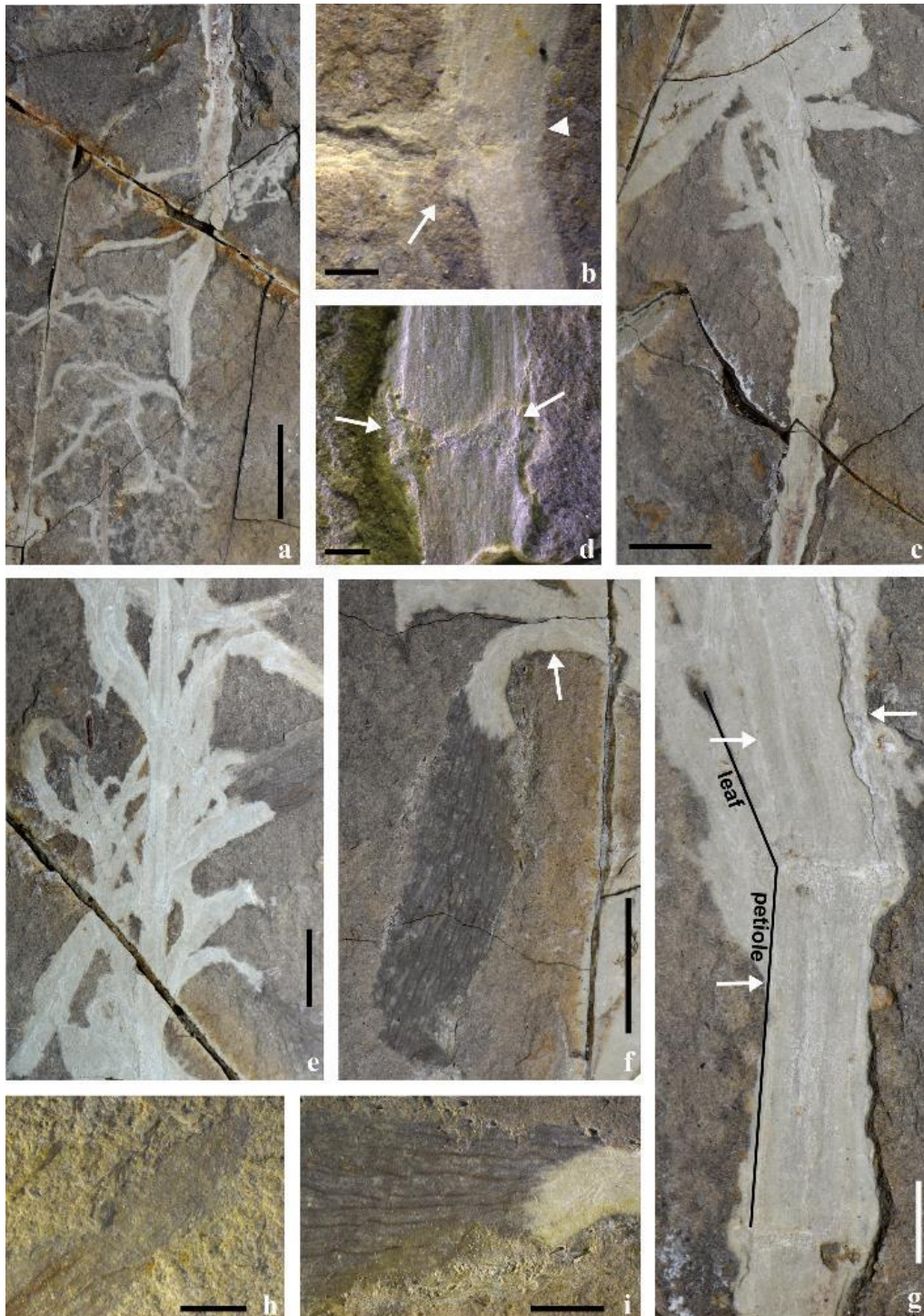


Figure 3. The vegetative organs of *Sinoherba* gen. nov. **a.** Fibrous roots are borne on the apex and nodes of an underground stem. Bar = 1 cm. **b.** A root (arrow) is borne on a node (arrowhead). Bar = 1 mm. **c.** A stem with swollen nodes and some nodes without leaves. Bar = 1 cm. **d.** A node with leaf scars (arrows). Bar = 1 mm. **e.** The stem together with a branch at the node. Bar = 1 cm. **f.** A leaf with parallel venation attached to a node. Note the leaf base that is contracted into the petiole (arrow). Bar = 1 cm. **g.** The petiole of a leaf clasping the stem (arrows). Bar = 3 mm. **h.** The apex of a leaf. Bar = 1 mm. **i.** Detailed view of the venation of the leaf shown in (f). Bar = 2 mm.

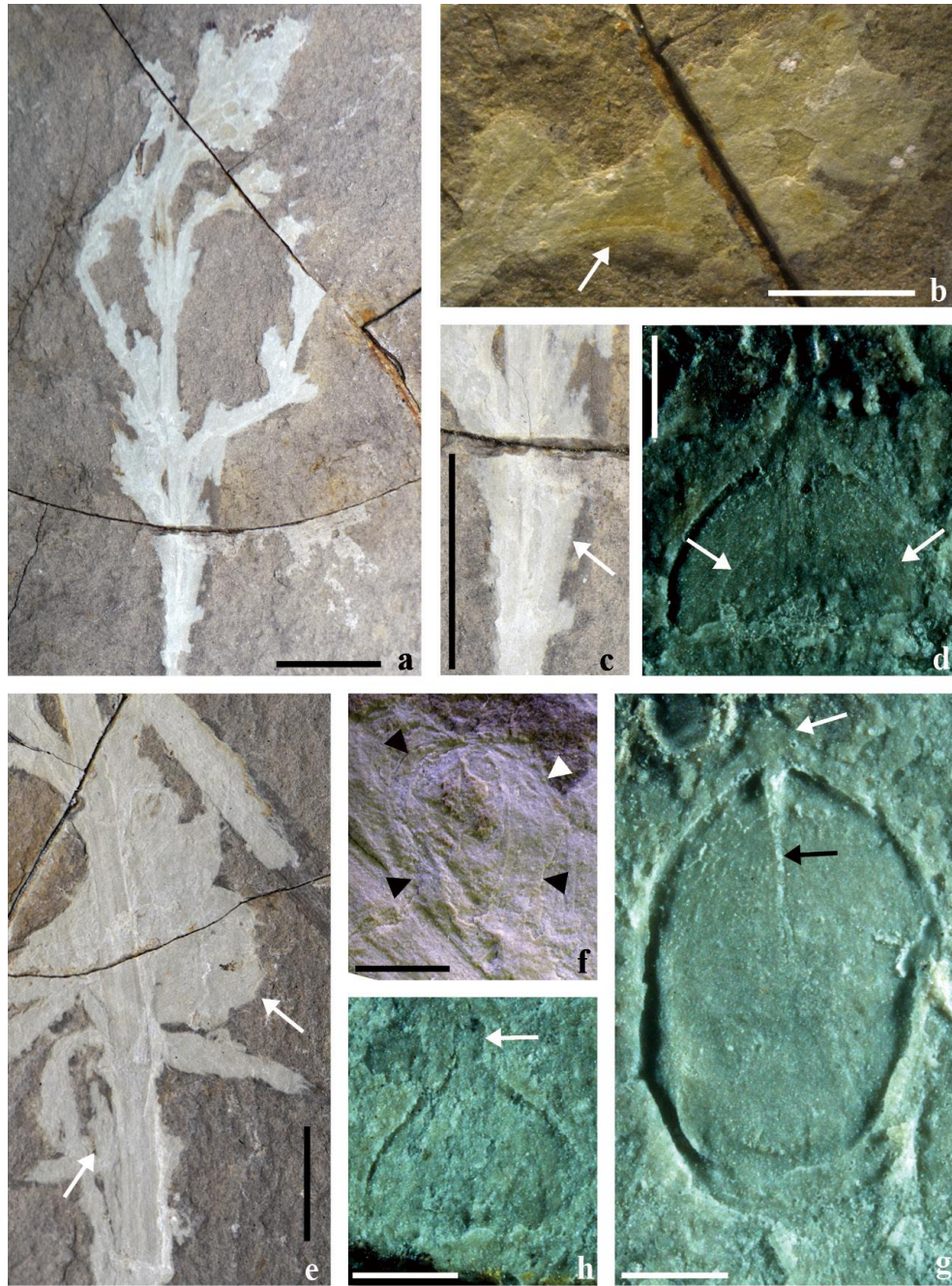


Figure 4. The reproductive organs of *Sinoherba* gen. nov. **a.** A panicle with many flowers. Bar = 1 cm. **b.** Flowers borne on a pedicel (arrow). Bar = 2 mm. **c.** A bract at the base of an inflorescence (arrow). Bar = 1 cm. **d.** An ovary with basal ovule (arrows). Bar = 0.5 mm. **e.** An inflorescence arisen from the axils of a leaf (arrows). Bar = 1 cm. **f.** A flower of the inflorescence from the axil of a leaf on the stem in Fig. 4e, showing the ovary surrounded by approximately three layers of perianths (arrowheads). Bar = 2 mm. **g.** An ovary split through its centre, showing its style (white arrow) and half septum (black arrow). Bar = 0.5 mm. **h.** Detailed view of the distal portion of an ovary, showing the distal style (arrow) on the ovary. Bar = 0.5 mm.

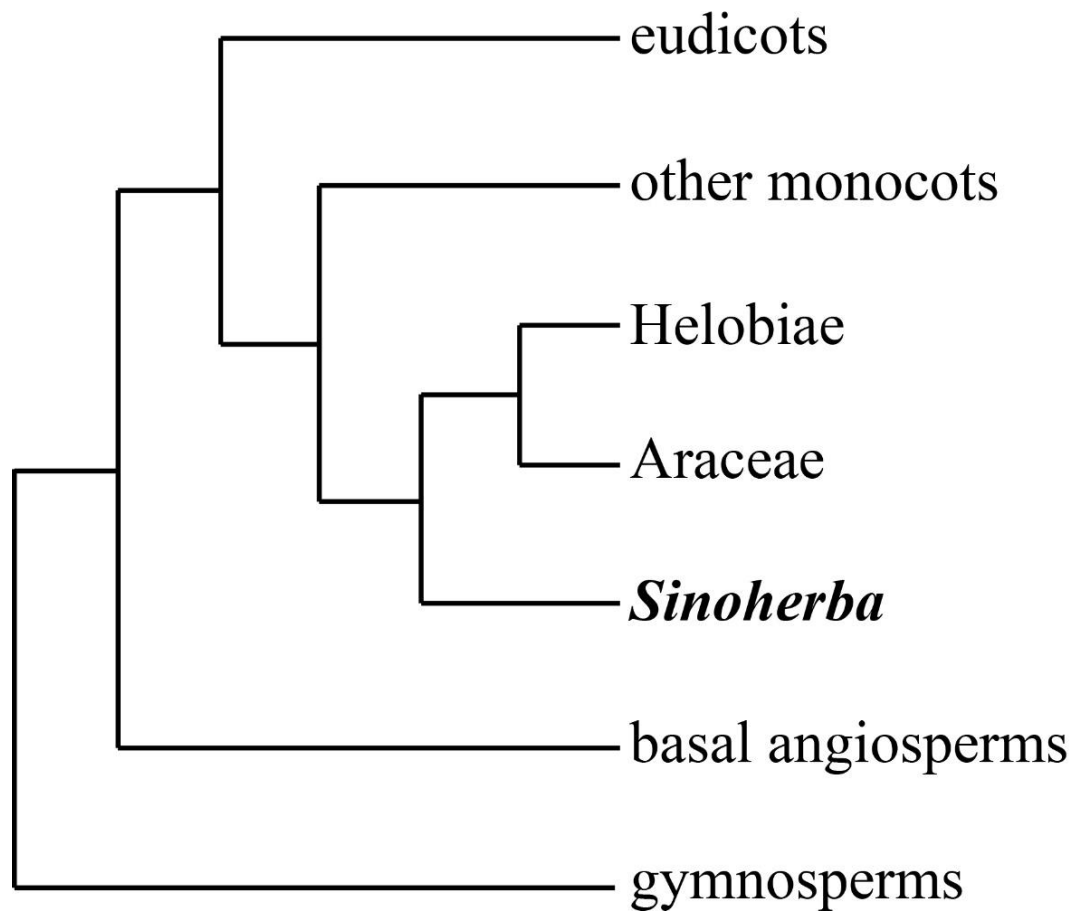


Figure 5. A phylogenetic tree (simplified) was reconstructed using a combination of morphological characters and plastid DNA regions (see details in Supplementary Fig. 2).

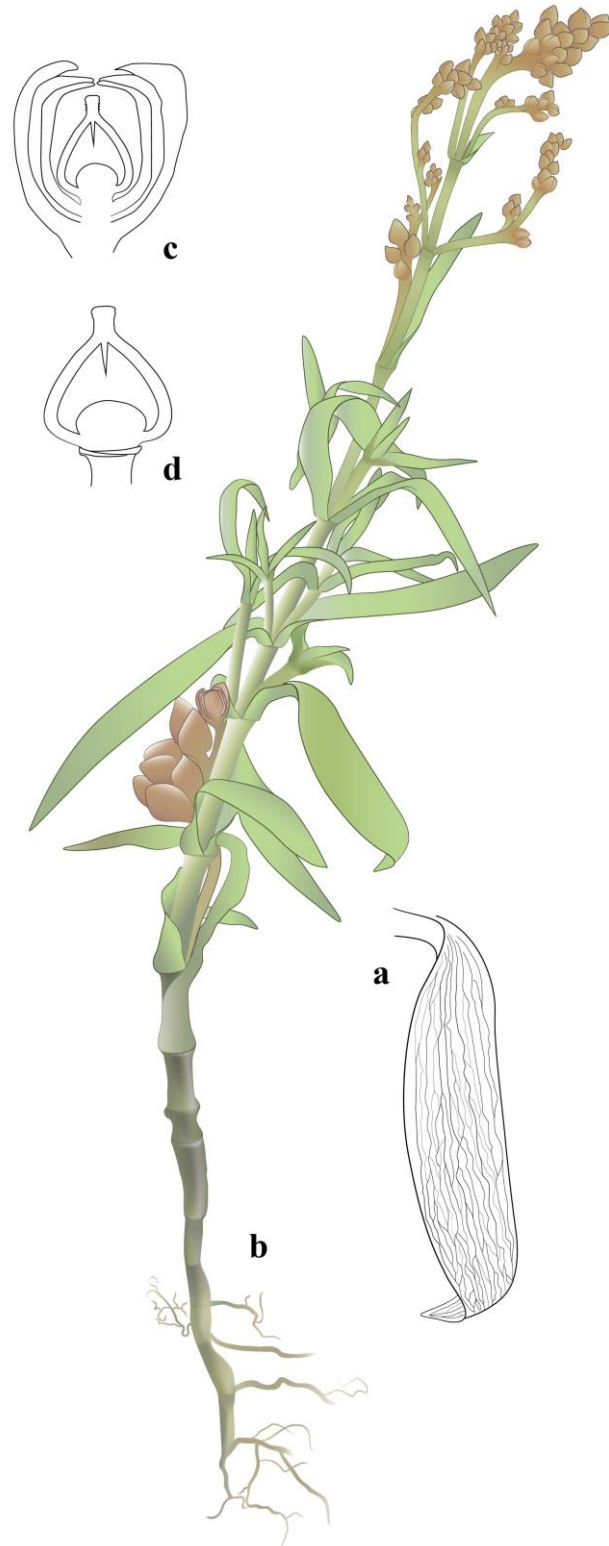


Figure 6. Reconstruction of *Sinoherba ningchengensis* gen et sp. nov. The plant is herbaceous and is composed of an underground stem with fibrous rootlets borne on the nodes, a stem with leaves (a) and branches in axils of bracts borne on the nodes, and inflorescences that both protrude from the axils of the leaves and are borne on the terminal stem (b). The pistil is surrounded by perianth (c) and the ovule on the bottom of the ovary (d). The colour of the flower was artificially created.

Supplementary Information

Table S1. Taxa and value information.

No.	Taxa	Characters
1	Vojnovskyales	1?1?16???0???353011?1103000340600??10110?1400200??032???0???74042?705105?000150300?0100?
2	Caytoniales	1?1?1????1?0?3530?1?110210?030111?01211102400200010320500000?31040423501103?000121100?0100?
3	Corystospermales	(1 2)?1?160??1?0(0 3)353011?11?01??03(0 1)5(0 1)02(0 3)1211102400200010320500000?31040423501103?000111200?0100?
4	Peltaspermales	1?1?130??0?0?353011?11?01??030(1 3 4)(0 1)0(0 2)(0 1)1211102400200010320202000?31740423501105?000110310?0100?
5	Glossopteridales	1?1?1601?0(1 2)0(0 3)353011?110(2 3)0?00305(0 1)10012111024002001103201(0 2)(0 1)000?3054042350(0 1)10500011(0 2)1(3 4)(0 1)0000002
6	Pentoxylales	(1 3)?1?1(6 7)015110(0 3)353011?110300?0307110(0 1)121110101020?0103204?2000?31740423505005?000150300?0100?
7	Utrechtiaceae	1?10160??100?353011?11(0 1)(2 3)000440(3 8 B)102(0 3)1111100400200122301010000?3174042350511510001(1 2)030110100?
8	Ullmanniaceae	1?10?60???0???353011?110???????5 9)??2?121110?40020012?3202?1??0?3174042350511510?012030??0000?
9	Stachyotaxus	1?10?601??0???353011????????????121110?400200???32?????0?31740423505105?00012030??0100?
10	Palissyaceae	1?10?60???0???353011????????????12111??400200???32?????0?31740423505105?0?012030??0100?
11	Emporiaceae	1?1016015000(0 3)353011011(0 1)3000?????2(0 3)1?101024002001123201?1000???74042350515???01?????????0
12	Thucydiaceae	1?101601??00?35301101103000540(3 8)0010111010?4002001223205?1000?31740423505105?0?010030??0000?
13	Trichopitys	1?101?01?0???3530?1?11030004?0400??12?01(0 1)040020012232??02??0?317404235051?5?00015??00?0000?
14	Cordaitales	101016015000(0 3)353011?1103000(3 4)40(3 7)00(0 2)11?11(0 1)02400200??22320201000?31740423505005100010030000100?
15	Lyginopteris	2?1016(0 1)1?01013530111111?(0 3)100(0 4)104002?12?1100400200022320202000931740423505105001010100000000?
16	Medullosans	(1 2)?101711?0101353011?110(0 3)1000101100012?110240020002232020200093174042350520500001(0 1)030000000?
17	Primocycas	?00???????3530???????00???????120???????2????232?????404235051?5?00012??00?0000?
18	Cycadaceae	1?00171??0(0 1)01353010?110310044(0 1)5100?120111(0 1)400200012320202000?3174042350510500001(2 3)0300000002
19	Zamia	1?00171??00?13530?0??103100???????120???????2??0123202?20?0?317404235051?5000013??00?00002
20	Encephalartos	1?00171??00?13530?0??103100???????120???????2??0123202?20?0?317404235051?5000013??00?00002

21	Yimaia	1?101????1???3530?1?????00???????12??????2????232????2?0?317404235151?5?00015??00?0100?
22	Ginkgo	1110160??10?(0 3)353011??103?00?0?0??0121??????2??012320502000?317404235151?5000010?000(0 1)100(1 2)
23	Ferugliocladaceae	1?10?60??0??353011?11030??40(3 C)10??121110?400200??32??1??0?31740423505105?0?012030??0000?
24	Majonicaceae	1?10?60??0??353011?1113??????2?121110????2????32?????0?3174042350512??0?01(1 2 3)0301??00?
25	Cephalotaxaceae	1?1016015?00?353011?110(1 2 3)00?5403100?121110?40020012?3200?2000?317404235051051000120301001002
26	Schizolepis	1?10?60??0??353011????????????121110????2????32?????0?31740423505115?00012030??0100?
27	Pinaceae	1?1016015100(0 3)3530111110(0 1 2)00?540(3 B)102?1(1 2)1110140020012?3202?(0 1 4 5)000?31740423505115100012030100100(0 1 2)
28	Taxodiaceae	1?1016015000?353011?110300?540(1 3)10(0 2)?121110?40020002?3202?2000?3174042350510010?0120301100000
29	Cupressaceae	1?1016015000?353011?111(1 2 4)00?5408?0(0 2)?1(1 2)1110?40020011?3202?2000?31740423505105100012030100100(0 2)
30	Podocarpaceae	(1 3)?1016015000(0 3)353011?110(1 2)00?540(3 9)1020121110(0 1)4002001103202?(0 1 4 5)000?317404235051151000120301001002
31	Araucariaceae	1?1116015000?3530110110(2 3)00?(3 4)40(5 9)10??1(1 2)111014002001103202?2000?317404235051151000120301001001
32	Bennettitales	1?1?160?000(0 3)353011?110310?0?(0 1)1(0 1)(0 1)?11(0 2)11(0 1)000002000103201020?0?3174042150510??000150310?01002
33	Ephedra	(1 3)?11160??0112?1111?110(2 4)00?340800??12111102002000103205?200(0 1)??740421505105100010?010010002
34	Gnetum	(1 2)?111(3 6)??0111?1111?110400?0?0911??12111102002000103205?201????740421505005101010?010110002
35	Welwitschia	3?111(3 6)??0111??111?110400?????1001(0 2)111104002000103205?200????740421505105101010?010100002
36	Archaeofructus	0?1?0?22?0????????11010??440400??1011001400200010?001?110????00102030(0 1)?01?00112030????00?
37	Nymphaeaceae	02110A22(2 3)01020030?13110300(0 1)6?0D01101011001100000010000502(0 2)???10(0 2)02313?00(0 1)4000115030101100(2 3)
38	Hydatellaceae	04110?22?0?1?0??1?1?1100000740300?01111011400000010?00502(0 2)???1500031B1200(0 6)100112030111000?
39	Cyclanthaceae	(0 2 3)?1106?2??1?0??1?1?1100(0 1)0?(6 7)?040??211111112(0 1)00100101005?20?????2(2 3)0331(3 B)10?1310011(2 5)0301011003
40	Illiciaceae	(1 3)0111601?0?1?01?1?1111000000?(0 1)9110(0 1)10110(0 1)1000000(0 1)0(0 2)0050200100?0000400020101001150301111002
41	Sinoherba	0?1?0?22?0????????110200?340(3 5)01??12?111????0????????????500331202???0?11003???????
42	Magnoliaceae	(1 3)(2 3 5)111601?0011(0 2)11111(0 1)11030010?09110(0 1)1011001000000010(0 1 2)00502001(3 6 7)4(0 1)00002001101(0 3 7)1001150301111002
43	Amborellaceae	(1 3)0111601?000?353011?110(0 3)0000?(0 1)9110(0 1)12111(0 1)100(0 1)0100100005020117?000103101200(8 9)1001100301111002
44	Primulaceae	00110(6 7)22?00112421113110(0 1 2)0000?(0 3)911(0 1 2)010110(0 1)11110000110005(0 2)(3 C Z)0(0 1)101?1(0 2)0331(4 B)00(0 1)(1 2)1100110030111100(2 3)
45	Brassicaceae	(0 1 3)(0 2 3)11(0 1)6?(1 2)?001(0 1)14(0 1)1?1111000(0 1)1?(0 1)(4 5)11(0 2)(B D)10110(0 1)12001050(0 1)(0 1)00(0 1)5020(0 1)1001(2 4)013313100(1 2)A1001120301110002
46	Monimiaceae	(1 2 3)01116?1?001(0 1)1(0 4)(1 2)111110(1 4)0000?(0 1)9110(0 1)1(0 1 2 4)11(0 1)(0 1)1(0 1 2)0001(0 5)010(0 2)(0 1)05(0 1 4)2(0 2)01(1 4 A)11(0 6)(0 3)0(0 2)(3 5)1(A B)(0 1)2(0

		1)1(6 8 9)100110030111110(1 2)
47	Basellaceae	041106?2?00111??1?110(0 1)000(0 6)?09112(0 1)1(0 1)11(0 1)111(0 1)101001020(0 1)5(0 2)2001401300331A0402B1001100301110002
48	Piperaceae	(1 2 3)(2 3)1116?1?00112??1?0?110(0 3)000(0 6)?09110(0 5 B)10110114222000002005020117?0(2 4)00331A02003000110030111100?
49	Lauraceae	(1 2 3)01116?1?001(0 1)241101(0 1)110(0 1)2)000(0 6)?(0 1 4)9110(0 1)1(0 2)11(0 1)(0 1)1500015010(0 2)(0 1)05120014?15(0 3)0431B(0 1)(4 6)0(0 1)(3 8)1001100301110(0 1)0?
50	Gyrostemonaceae	(1 3)?1116?1?001(2 3)142111(0 1)110(0 3)00(0 1)0?0(3 5 9)11(0 2)012111(0 1)130000001000502(3 9)0?1???0 6)00(0 1)30(0 1 2)?201(2 6)1001150301111002
51	Chloranthaceae	(0 1 3)(0 2)11(0 1)6?1?00110011(0 1)1(0 1)11010010?1911011(0 2)110103000000101(0 1)05(0 1)20(0 1)10005(0 1)0431B?201(7 8 9)1001100301111002
52	Phytolaccaceae	(0 1 2 3)011(0 1)6?1?001(1 3)24(0 1)1111110(0 3)00(0 1)0?0911(0 2)(0 1)1(0 2)11(0 1)(0 1)(0 1)(1 2)001000(0 1)0001502001601(0 6)01(0 2)31A?202(3 8)100110030111100?
53	Cucurbitaceae	(0 2)211(0 1)6?1?00111??1?1?110(0 3)(0 1)0(0 1)6?(0 3)011(0 2)01(1 2)111(0 1)1110160002(0 1)0502(0 2)01(0 1 4)?3302313100131001150301110002
54	Alismataceae	04110A22?000?3530?1?11(0 1)0000(0 3 6)40300?(1 2)1(0 1)11(0 1)1150000(1 5 7)010(1 2)00502001(0 4)??(0 3)000(3 5)1(1 2 A)?(3 6)0(0 1 4)(0 6 9)1001100301111003
55	Amaryllidaceae	04110A22?000?0530?1?1100000340310?010110(0 1)15(0 1)(0 1)0070(0 1)0(0 1)0(0 1)5(0 2)2(1 2)(0 2)01(0 4)?330331(1 2)?0(0 1)1(1 3)1001150301111001
56	Najadaceae	04110A22?000?3530?1?110100(0 1)7?(0 1)3104F1(1 2)11101200000000?(0 4)05?2(0 3)014?1500031A?20161001100301111003
57	Hydrocharitaceae	04110A22?001?0?0?11110(0 1 2)000(0 3 6 7)40(3 D)(0 1)0?11(0 1 2)110(0 1)150000(1 2 5)0(0 1)0(1 2)(0 1)0502(0 2)0(0 1)(4 F)?1(0 3)30231(3 A C)?00(0 1)3100115030111(0 1)003
58	Hamaelidaceae	(1 3)21116?1?00100111?11110(0 3)001(0 6)?(0 3)D11(0 1)11(0 1 2)11(0 1)11(1 2)(0 1)0(0 1)(0 1)20000005(0 1 2)20(0 1)(0 1)0004(0 2)02311?101(0 1)1001150301111002
59	Gomortegaceae	101116?1?00100??1?1111010000?091101101101?3000100000105120????(3 4)30231B12?181001100301111002
60	Eupomatiaceae	(1 3)(3 5)1116?1?00110?11?1?1100000?09110110110(0 1)1400010000005020?????0203313?0019100112030111(0 1)002
61	Grossulariaceae	321116?1?1011242111110000(0 1)(0 6)?1011011(0 2)1(0 1)(0 1)(0 1)1(1 2)100100000005020016?04303313?(0 1)0131001120301111002
62	Iteaceae	(1 3)21116?1?001(1 3)00?1?11110(0 3)00(0 1)0?1911?11011011100(0 1)110100015020016?04(0 3)0131(1 2)?(0 1)0101001150301111002
63	Penaecaceae	(0 1 3)01116?1?00102??1?1?110(1 4)00(0 1)0?0911(0 2)(0 B)10110012000100100005020?????200331(1 2 A B)?101111011(0 5)0301110002
64	Parnassiaceae	00110722?00??1????1?110(0 3)0006?0E11?010110(0 1)1100(0 1)050112025020(0 1)1(0 8)012(0 3)03213(0 1)001(0 1)1001120301110002
65	Ulmaceae	12111601?001(0 1)142101(0 1)11000010?1911001(0 1 2)11(0 1)113(0 1)(0 1)0100102015020(0 1)1301430330B1201(2 7)1001100301110002
66	Turneraceae	(0 1 3)21116?(1 2)?001024?111(0 1)110000(0 1)0?0(0 1)9110(0 B)10110(0 1)1100116001000502001001(2 3)00(2 3)313?001(0 1)1001120301111002
67	Neuradaceae	021106?2?001?23?1?1?110000(0 1)(0 6)?(0 1)9110010110011101?010001502001000(0 6)(2 3)0231(1 B)?10(0 1)010011(0 5)0301110002
68	Nitrariaceae	321116?1?001?23?1110110(0 3)00(0 1)(6 7)?(0 3)5112(0 1 5)101101111001?0100005020016??(0 6)00331(1 B)?20(0 1)(3 8)10011(0 5)0301110002
69	Symplocaceae	(1 3)01116?1?00100(1 4)?111110(0 3)0000?0911011(0 1)110(0 1)111100?01100152(3 9)001011(0 6)(2 3)03311?111(3 8)1001150301111002
70	Portulacaceae	(0 3)01106?(1 2)?001(0 1)271101?110(0 1)00(0 1)(0 7)?0(3 5 9)11(0 2)(0 1 C)10110(0 1)11(0 1)(0 1)012010000502001401(3 4)(0 3)033(1 2)(4 A)?00(1 2)(0 1)10011(0 5)0301110002
71	Aizoaceae	(0 3)0110622?001?2?11113110(0 1)0000?0911?(1 B)10110(0 1)11000120(0 1)000050200141?6(0 3)0(0 2)3(1 2)2?(0 1)0(1 2)(0 1)1001150301110002

72	Cactaceae	(1 3)01116?1?1011111(0 1)?1?0205200042A003(1 C)10110(0 1)000001(2 6)0100005020014113(0 3)0331(3 A)?002310011(0 2)0301110002
73	Onagraceae	(0 1 3)011(0 1)6?1?0010242?11110(0 1 2)00(0 1)0?(0 1)511(0 1 2)(2 5 B)10110(0 1)1(2 3)00112010001502(0 2)01(0 6)(0 2)1230331(1 2)?(0 1)01(1 2 3)1001150301110002
74	Trapaceae	041106?(1 2)?001?1421?011111(0 1)01(0 6)?(0 1)611(0 2)?101100121000?000001502001(0 1)?00331(1 2)?201(2 8)0001150300010002
75	Myrtaceae	(1 3)01116??00100??11?110(0 1 2)0000?(0 1)511(1 2)010110(0 1)13(0 1)(0 1)0120(0 1)(0 1)0(0 3 4)15(0 2)20(0 1)1(6 B)206(2 3)0131(1 2 3)?00(1 2)(0 1 2)10011(2 5)0301110002
76	Melastomataceae	(0 2 3)011(0 1)6?(1 2)?001024?111(0 1)11(0 1)10003?(0 1)501(0 2)(0 1 7 B)1011011(1 2 5)1001601(0 1)0005(0 2)20(0 1)16?1(0 6)(0 3)0331(1 2 A)?00(1 2)(1 3)1001150301110002
77	Combretaceae	(1 2 3)011(0 1)6?1?001014?1(0 1)1(0 1)110(0 1 2)0000?0511(0 1)(0 1 5)1(0 6)11(0 1)(0 1)1(1 2)(0 1)001(2 6)0100015020(0 1)1(3 6)11630331B?1018100110030111001(1 2 3) (0 2 3)?110A22?001?20?1?1?11(0 1)(0 3)00(0 1)(0 3 6)?0310(0 2)11(0 1 2)110(0 1)13(0 1)00000(0 1)0(0 1 2)0(0 1)5(0 2)2001(0 4 6)11(3 4)00331(A B)121(0 1 2)(2 6 B
78	Poaceae	C)1001100301111001
79	Orchidaceae	04110A22?001?2??1?1?110(0 1 2)0(0 1)03?0(3 8)00?(0 1 2)10110(0 1)15(0 1)(0 1)01(3 7)000(0 1)0(0 1)502(0 2 3)01(0 4 6 F)?1330331(1 2 3)?001(1 3)00011(2 5)0301110003
80	Araceae	04110A?2?001?0??0?1100(0 1)(0 1)0(0 3 6)?00(0 1)?(0 1 2 5)1(0 5 7 8 9)11(0 1)113(0 1)00000(0 1)02(0 1)05(0 2)22(0 1)1(0 6 B)41(3 4 5)00331(3 A B)(0 1)(0 1)0(0 1)(2 3 8 B)11011(0 2)030111(0 1)003
81	Cyperaceae	04110A?2?001?2??1?0?11000003?(0 1)310?11(0 4 7 8 9)11(0 1)11300000000(0 1)005?2(0 2)01(4 6)?0(3 4)00(2 3)31(A B)0201(2 6 8)1101100301111003
82	Iridaceae	(0 3)?11(0 1)A?(1 2)?001?1??(0 1)?0?11000(0 1)03?0310?010110(0 1)150001(3 5 7 8)0(0 1)020(0 1)502(0 2)(0 1)1(0 4)113(0 3)01312?(0 1)0111001150301111001
83	Winteraceae	(1 3)(1 2)1116?1?00003530110110(0 3)0000005110110110(0 1)10(0 1)(0 1)000010(0 1 2)00502(0 2)01100000000000101001120301111002
84	Eupteleaceae	(1 3)01116?1?001(0 1)0111111110(0 3)000211911001(0 9)11(0 1)014000000101005(0 1)20013000010200?10121001120301111002
85	Papaveraceae	(0 1 3)(1 2)1116?1?00112421?11110(0 2)00001(0 3)011(0 2)010110(0 1)1(2 3)(0 1)00(0 1)(0 2)000?00502(0 2)01(0 3)1(0 1)(0 4)0(0 1)(2 3)(1 2)1(0 3)?(0 1)01(0 2)1001150301111002 (0 2 3)(0 2 3)11(0 1)6?1?0011240111?11(0 1)(0 1 2)(0 1)0(0 1)(0 6)1(0 1 3)911(0 1 2)01(0 2)11(0 1)(0 1)(0 1)3(0 1)(0 1)(0 1)020(0 1)0(1 2)005(0 1)0(0 1)1(0 1 4 5 7)2(0 1)(0 3 5)000(1 2)11?0(0 1)1(0 2 3)100112030111100(2 3)
86	Ranunculaceae	
87	Sabiaceae	(1 2 3)?11(0 1)6?(1 2)?001(0 1)14011111100000(0 6)009110(0 1)1011011(0 1)00002010(0 2)0050201100(0 1)400311(1 B)131(0 1)(2 3)10011(0 5)0301110002
88	Platanaceae	131116?1?001122111111100001114011?011111101000000101005120(0 1)10000000210?(2 3)00(2 6 9)1001120301111002
89	Proteaceae	(0 1 3)21116?1?0011241111211(0 1)(0 1 2 3)(0 1)00(0 3 6 7)2(0 3)911(0 2)110110(0 1)(0 1)(1 2)100(0 1)20(0 1)(0 1)(0 1)005020(0 1)101050(0 1)431(0 B)?(0 1)0(0 1)(0 6 8)10011(0 2)0301111002
90	Trochodendraceae	1(0 3 5)111601?000(0 1)353011(0 1)1100000(0 1)019110(1 2 4)1(0 4)11(0 1)1(0 1)(0 2)000010101005120(0 1)1100(0 2)201000?001(0 9)1001120301111002
91	Buxaceae	(0 1 3)011?6?1?001(0 1 3)020(0 1)111110(0 1)00000(0 1)911051(1 2)111(0 1)(0 1)20000101000(0 1)502001300(2 3)102001?300(1 8)1001150301111002
92	Gunneraceae	04110722?001?10?111?110000(0 1)(0 1)0(0 2)(0 1)(0 9 D)01201(1 2)11111300000010(0 2)0050201162?430(2 3)1011201(2 3)1001150301111002
93	Myrothamnaceae	3?1116?1?001002111111101001110911?012111102000000(0 1)01005020012?0(2 3)001000?00101001120301111002

94	Dilleniaceae	(0 1 2 3)(0 2 3 5)11(0 1)6?1?00112111?1(0 1)110(0 1 3)00(0 1)(0 7)2(0 1 3)911?(0 1)10110011000(0 1)(0 2)0(0 1)(0 1)(0 1)000(0 2)20(0 1)1810(0 6)0(0 1)(0 1)11(0 1 A)?101(0 3 6 9)10011(0 5)0301111002
95	Erythralaceae	(1 2 3)?1116?1?001?2(2 4)111111(0 1)00000(0 3)09110(0 1 5)101101111001200100050231101(0 1)330(2 3)11(A B)(0 1)2113100110030111100?
96	Olacaceae	(1 2 3)(0 2 3)1116?1?001?041111(0 1)110(0 1 3)000(0 7)00911(0 2)(0 1 5)1(0 6)11(0 1)(0 1)(0 1)31(0 1)0(0 1)(1 6)0(0 1)(0 1)?005(0 2)20(0 1)1(0 7)11(2 3 4)(0 2)0311(1 4 B)?2(0 1 2)1(2 3)10011(0 5)030111100(0 1 2)
97	Aextoxicaceae	121116?1?001?0(0 4)11?10110(0 1 2)000000911?512111111001020100005020116??4003111130181001150301111002
98	Berberidaceae	2(2 3)1116?1?00112(0 4)0?1?10110(0 3)000(0 6)0(0 1)9110510110(0 1)13000020(0 1)0200512(0 2)(0 1)1(1 3 8)(0 2)0300311(3 A)(0 1)00(0 1)3100112030111100?
99	Caryophyllaceae	(0 1 3)011(0 1)6?1?001(0 1)1301?1?110(0 1 2)000000(3 5)11(0 2)(7 B)1(0 1 2)11(0 1)(0 1)1(1 2)(0 1)001(0 2)01(0 1)00(0 1)502001(0 2 4 6)1(0 1)(1 4)002(0 1)12?(0 1)112100115030111(0 1)002
100	Nepenthaceae	(0 2 3)?1116?1?001(1 3)140111111(0 1)(0 3)0003?0(3 7)11001211111200003000202502(0 2)11420200211(1 2)000111001150301111002
101	Fouquieriaceae	(1 3)01116?1?101?2411?12110000000051120101101110100201(0 1)0015020010003003110?1011100112030111(0 1)002
102	Polemoniaceae	(0 1 3)011(0 1)6?1?00102421?11110(0 1 2)(0 1)0000(0 1)(3 5)11(0 2)(0 1)10110(0 1)(0 1)11100201000050001(0 1)003003110?(0 1)1111001120301111002
103	Theaceae	(1 3)01116?1?00100101110110(0 3)00000(0 1)9110(0 5)10110011(0 1)(0 1)0020(0 1)0(0 1)0(0 1)5020(0 1)14106(0 3)0(2 3)110?00(1 2)01001120301111002
104	Actinidiaceae	(1 2 3)(0 2)1116?1?101022(0 1)1?10110(0 3)00(0 1)010(5 9)11001211(0 1)(0 1)1(1 2)100000100?15(0 2)2(0 2)11(6 7)200002110?011(1 4)1001120301111002
105	Sarraceniaceae	04110622?001?0011?1211(0 1)(0 3)000??0G11?010110(0 1)11000020(0 1)000(0 1)50200171?3003110?0(0 1)111001120301111002
106	Clethraceae	(1 3)01116?1?00100201110110(0 3)0000019110(0 1 B)1011011111002010(0 2)01522?016203003110?01111001120301111002
107	Ericaceae	(1 2 3)(0 2)11(0 1)6?1?001022(0 1 2)1111110(0 1)000(0 6 7)00(3 5 9)111(0 1 5)10110(0 1)(0 1)1(0 1)(0 1)00(2 6)010(0 1)0(0 1)5(0 2)2(0 2)01620130311(1 B)?01(0 1 2)(0 1 2 3 8)10011(0 5)0301111002
108	Cornaceae	(0 1 3)21116?1?001002111101101000130911001011(0 1)1(0 1)210012010001502(0 2)018104303111?211(3 8)1001150301111002
109	Alangiaceae	(1 2 3)21116?1?0010(0 2)421?1(0 1)1100000(0 1)30011001(0 2)11(0 1)11(1 2)1(0 1)00201000(0 1)502001(0 3)10(3 4)30311B?2(0 1)131001100301111002
110	Nyssaceae	(1 3)21116?1?001?02111101100000030911011(0 1 2)11110100002010(0 1)00500018104303101?211(7 8)1001150301111002
111	Loasaceae	(0 1 3)?11(0 1)6?(1 2)?001(0 1)1001?12110(0 1)00012(0 3)(0 4)11?010110(0 1)(0 1)100112010?005030?11103303113?01111001120301111002
112	Hydrangeaceae	(0 2 3)?11(0 1)6?1?001(0 1)2011?101101000201911?1101101(0 1)(1 2)100(0 1)20(0 1)00?(0 1)502011000630211(0 3)?11111001120301111002
113	Eucommiaceae	101116?1?0010230111110000000191100121111100000(0 3)010?0050200162(0 1)4003101?31121001150301111002
114	Garryaceae	(1 3)21116?1?00111(2 4)0111211010001319110112111112(0 1)00000100005020010004302113?21131001100301111002
115	Rubiaceae	(0 1 2 3)?11(0 1)6?(1 2)?001(0 1 3)1411111110(1 2)0010009110110110(0 1)(0 1)(1 2)110000(0 1)0000502(0 2)(0 1)10004303110?111(0 4)100112030111(0 1)002

116	Loganiaceae	(0 3)(0 2 3)1116?1?001(0 1)1421(0 1)1(1 2)11010010005110(0 1 B)10110(0 1)111100(0 2 6)0100?15020(0 1)1000(3 4)003111?01101001150301111002
117	Solanaceae	(0 1 2 3)01116?1?001(0 1)2?21112110(0 1 3)00000(0 3)(0 4)11(0 2)(0 7 B)1(0 1 2)11(0 1)(0 1)1(1 2)1100201(0 1)(0 2)0(0 1)502(0 2)01(1 3 4)104003110?011(0 4)1001120301111002
118	Taccaceae	04110A?2?000?3530?1?110(0 3)(0 1)00(0 6)40(5 9)110(0 E)10110115110100000005020011??3303313?01(1 2)(1 3)0001120001111003
119	Philydraceae	04110A?2?000?3530?1?1100010340(3 5)000(0 1 2)1011010510000010(0 1 2)01502(2 3)01F?1300331(1 B)?001(1 3)00011(0 5)0301111001
120	Velloziaceae	(0 1)?110A?2?001?2??1?1?1103000341310(0 2)(1 2)10110(0 1)15000110(0 1)0(0 1 2)?(0 1)302(0 2 3)????330331(2 C)100110001150301111001
121	Juncaceae	(0 3)?110A?2?001?2??1?0?11000(0 1)(0 1)340(3 H)00?11(0 2)11(0 1)11500000000(0 1)(0 1)050220?(4 6)?030133(1 2)(2 3 A B)1001(1 4 6)10011(0 5)0301111003
122	Scrophulariaceae	(0 1 2 3)011(0 1)6?(1 2)?00102421?1(0 2)11(0 1)(0 1)00102(1 3)911(0 1 2)(0 7 B)10110(0 1)(0 1)11100(2 6)0(0 1)00(0 1)15(0 2)20010104003110101101001120301111002
123	Aquifoliaceae	(1 3)(0 1)1116?1?0011(0 1)221?1011(0 1)(0 1)2)00(0 1)01(1 3)911001(0 1 2)110(0 1)1(1 2)1(0 1)002010001502001(0 2)00(0 4)003(1 2)11?(2 3)1131001150301111002
124	Campanulaceae	(0 1 3)01116?1?00102421?121100(0 1)000?1911(0 1 2)010110(0 1)(0 1)(1 2)110020(0 1)0000502001(6 8)106303110?01101001120301111002
125	Alseuosmiaceae	3?1116?1?00110(1 4)1101111000000(0 2)15110010110110101201(0 1)0?15020016204303110?11141001120301111002
126	Escalloniaceae	(1 3)(0 2)1116?1?001(0 1 3)011111011000000(0 2)(0 1)911?0101101111(0 1)1(0 1)20100015020113104(0 3)0311(0 3)?011(0 3)10011(2 5)030111100?
127	Bruniaceae	(1 3)?1116?1?0010011111(1 2)1?000003?08??(0 1)010110(0 1)(0 1)100020100?1502001000430211B?(2 3)11(0 2 4 6)1001100301111002
128	Araliaceae	(1 3)31116?1?001(0 1)0?21?1111001000?09112B101111(0 1)1(0 1)0(0 1)(0 1)20100(0 5)150200100(0 1)6302111?211(3 4)1001150301111002
129	Pittosporaceae	(1 2 3)(0 2)1116?1?00112421(0 1)10110000002(0 1)911(0 2)(1 5)1(0 1)11(0 1)(0 1)11(0 1)(0 1)020(0 1)000(0 1)0(0 2)2001000400311(1 2 3)?011110011(2 5)030111100(0 1 2)
130	Adoxaceae	04110622?00110401?1211011000200110010110(0 1)11110(0 1)20100115?20?10003303110?11131001120301111002
131	Caprifoliaceae	(0 1 2 3)(0 2)11(0 1)6?(0 1)?00102401?101101000000911001(0 1)11(0 1)(0 1)(0 1)111002011001502001420630311(1 2 3 B)?111410011(0 2 5)0301111002
132	Saxifragaceae	0(2 3)110622?001(0 1)2??111?110(0 1)000(0 6 7)2(0 1)(0 9)11(0 1 2)010110(0 1)(0 1)1(0 1)(0 1)(0 1)2011(0 1 2)0(0 1)502(0 2)(0 1)1(0 1)10(1 2 3 4)(0 1 2 3)0(0 1)31(1 2)?0(0 1)1(0 9)1001150301111002
133	Crassulaceae	(0 3)(0 2)11(0 1)6?(0 1)?001(0 1)27?1?1?110(1 2 3)(0 1)0002(0 1)9112(B D)10110(0 1)1(1 2)(0 1)(0 1)0120(0 1)0(0 1)005020(0 1)1110(1 2)200110?00101001120301111002
134	Penthoraceae	0011(0 1)62(1 2)?001?0(4 6)111121100000021511?01011011100110010110502011110(0 1)201110?0010100112030111100?
135	Tetracarpeae	301116?1?001?2111?1(0 1)110(0 3)0000(0 2)1911?010110112011100001?0502011510(1 2)010110?01101001120301111002
136	Altingiaceae	121116?1?001(0 3)010111(0 1)11000110(0 1)911?111111000000010?005(0 1)20010004302100?00101001120301111002
137	Cercidiphyllaceae	121116?1?10100111111101001101D1100121111(0 1)?000000101005020013005010200?00101001120301111002
138	Hamamelidaceae	(1 3)21116?1?0010010111(0 1)110001(0 6)0(0 1)911?11(0 1)11(0 1)101001(0 1)201000(0 1)5(0 1)2001000620210(1 2)?201(0 1)1001150301111002
139	Geraniaceae	(0 3)211(0 1)6?(1 2)?001(0 1)2321?1?110(0 1)(0 1)01011011(0 2)010110(0 1)10(0 1)010200(0 1)0015020(0 1)1(0 1)(0 1)0100(2 3)100?(2 3)0(1 2)41001120301110002
140	Lythraceae	(0 1 3)(0 2)11(0 1)6?(1 2)?00102411?1?110(0 1 2 3)00(0 1)000911(0 2)(0 B)10110(0 1)(0 1)200(0 1)1(2 6)01(0 1)0015020(0 1)1(0 1)10600311(1 2 3)?(2 3)01(0 1)10011(2

		5)0301110002
141	Staphyleaceae	(1 3)21116?1?0010011111(0 1)110(0 1)(0 1)010219110B1(0 1 2)11(0 1)1110000(2 6)010001500(0 1)10103(0 2)0(2 3)110?10101001120301111002
142	Crossosomataceae	3(0 2)1116?1?00102401112110(0 1 3)00(0 1)0?(0 1)911?01011(0 1)01(1 2)00102010(0 1 2)0(0 2)50200100060101(0 1)0?10(1 2 4)(0 9)0001120301111002
143	Picramniaceae	(1 3)(0 2)1116?1?001?2401?1?1100100000911001211111(1 2)10002010001502011110(3 4)20311(1 2)?(2 3)01(2 3)1001150301110002
144	Sapindaceae	(0 1 2 3)211(0 1)6?(1 2)?00102421?111100100021911?(0 1)1(1 5 6)111(0 1)1(1 2)(0 1)000001000(0 1 2)502(0 2)011103003110?201(0 1 2 3 4 7)1001120301111002
145	Tropaeolaceae	021106?2?00112(0 4)?1?1?110(0 1)(0 1)0(0 1)61(0 1)D01(0 1)010110013(0 1)0103011100502001(0 1)01300(2 3)1(0 1)1?201(2 3)1001150301110002
146	Thymelaeaceae	(0 1 2 3)011(0 1)6?(1 2)?0010241111?110(0 1 2)000000911?(0 5)1(0 1 2)11(0 1)(0 1)(0 1)(1 2)11012011000502001(0 3)00(0 1 4)003(0 1 2)1(1 2 3 B)?201(3 6 8)10011(2 5)030111(0 1)002
147	Vochysiaceae	(1 2 3)(0 2)11(0 1)6?(1 2)?001?24(0 1)111(0 1)110(0 1 2)0010009110(0 1)10110113(0 1)00060(0 1)00015020????330331(1 2)?(0 2)01(1 2)0001150301010002
148	Rosaceae	(0 1 2 3)(0 2 3 5)11(0 1)601?001(0 1)2411?12110000(0 1)(0 6)21911001(0 1 2)110(0 1)111001(2 6)0(0 1)0(0 1)015(0 2)2(0 2)011101(0 3)0(0 3)11(1 2 3 A B)?(0 1)(0 1)1(0 6 D)10011(0 2 5)0301110002
149	Rhamnaceae	(0 1 2 3)211(0 1)601?00102421?1(0 1)110(0 1)00(0 1)(0 6)21911(0 2)(0 1 B)10110(0 1)(0 1)(1 2)0011(2 6)010005(0 1)230(0 1)1810(4 5)(2 3)0311(1 2)?2018100115030111(0 1)002
150	Anisophyllaceae	(1 3)01116?1?001(0 1 3)241111(0 1)11(0 1)0000(0 6)00911?11011(0 1)(0 1)120010201000150230018102302110?211(2 8)10011203011110(0 1)(2 4)
151	Fagaceae	(1 3)21116?1?001(0 1)2311(0 1)0111000010119110011111(0 1)03(0 1)(0 1)0000100015020(0 1)15104302300?30121001120301110002
152	Betulaceae	(1 3)21116?1?001(0 1)04211011100001011911?011111102000000102005020014214202110?(2 3)112100112030111(0 1)002
153	Rhoipteleaceae	041116?1?001?14111111100101021511?01(0 7)10(0 1)10200005010?005020014214002102120(1 2)21001150301110002
154	Myricaceae	(1 3)(0 2)1116?1?00112211111110000001(0 1)511?01(1 2)111103000(0 1)00(0 1)02005020(0 1)14214302102?41031001150301110002
155	Juglandaceae	1(2 5)1116?1?0010141111(0 1)110(0 1)00(0 1)02(0 1)511001(1 2)11110200000010?(0 1)05020014214302102?41021001150301110002
156	Celastraceae	(1 2 3)011(0 1)6?1?001(0 1)24(0 1)111?110(0 1)00(0 1)001911(0 2)(0 1 2 5 B)1(0 1 2)11(0 1)11(1 2)100020(0 1)0(0 2)(0 1)0502(0 2)010006(0 2)0311(1 2)?(2 3)01(1 3 6 7 8)1001150301110002
157	Malphighiaceae	(1 2 3)(0 2)1116?1?00102421?1(0 1)110100(0 1)00(0 1)911(0 2)(0 1)1(0 5)11(0 1)111(0 1)01000000015(0 2)20010(1 2)0300(0 2)11(0 1 2 B)?201(2 4 7 8 9)10011(0 2 5)0301110002
158	Ochnaceae	(1 3)(2 3)1116?1?00102411?10110(0 3)00000(0 1)911?(0 1)1011011(1 2)00(0 1)000(0 1)01005(0 2)2300(6 7)10(0 6)003513?(0 1)010100112030111(0 1)002
159	Rhizophoraceae	(1 3)(2 3)1116?1?001(0 1)211111(0 1)110100100(0 1)9110(1 5 B)10110(0 1)1210(0 1)120(0 1)00015420(0 1)1(0 3 8)100303111?(0 1)0121001150301111012
160	Linaceae	(0 3)211(0 1)6?(1 2)?0010241111(0 1)110(0 1)00(0 1)0?(0 5 9)11011011011(1 2)(0 1)0(0 1)0200(0 1)00(0 1)502001(4 7)106003111?301(0 8)1001150301111002
161	Euphorbiaceae	(0 1 2 3)(0 2)11(0 1)6?(1 2)?001(0 1)2421110110(0 1 2 3)00122(0 1)(3 9)11(0 1 2)(0 1 B)1(0 1 2)11(0 1)(0 1)(0 1)10000(2 6)0(0 1)0(0 2)(0 1)05(0 2)20(0 1)1000300230(1 B)?(2 3)01(1 2 4 8)10011(0 5)0301111002

162	Oxalidaceae	0211(0 1)6?(1 2)?001(0 1)2411?1(0 2)1100100030911?110110(0 1)1101(0 1)12001001502001010100211(1 2)?101(1 9)1001120301111002
163	Connaraceae	(1 2 3)(0 2)1116?1?00102411?1211001000?09110(1 5 7 B)1011011(1 2)(0 1)(0 1)002011001500018101101110?301(0 9)100112030111(0 1)002
164	Brunelliaceae	1(2 5)1116?1?00101111?1(0 1)1101101011911001(0 2 8)11(0 1)111000020100015020118100101100?301(0 9)1001120301111002
165	Cunoniaceae	(1 2 3)21116?1?0010(0 2)(1 2)(0 1)11111010010(0 2)1911?(0 1)1(0 2 4 8)11(0 1)(0 1)(0 1)2(0 1)(0 1)002010001502011810410(1 2)11(1 2 B)?301(0 4)10011(2 5)0301111002
166	Davidsoniaceae	1(0 2 3)1116?1?001?2111?111100101611911?110110111100020100015020118104002111?10181001150301110002
167	Eucryphiaceae	(1 3)21116?1?00102111111101(0 1)01011911011011001200002010101502011810000211(1 2)?00101001150301111002
168	Baueraceae	301116?1?001?2211?11110(1 2)0000?1911??1011001(1 2)00002010001502011000420311(1 2 B)?101010011(0 5)0301111002
169	Fabaceae	(0 1 2)(2 5)11(0 1)6?(1 2)?001(0 1 3)241101011(0 1)(0 1 2 3)(0 1)0(0 1)(0 6)?09110(0 1 2 5)1(0 1)11(0 1)101(0 1)(0 1)1(0 1)000(0 1)(0 1)0(0 1)5(0 2)2(2 3)(0 1)10001002110?20(1 2 4)(0 2 6 7 8)100112000101(0 1)002

Table S2. Characters (The numbers in the parentheses are the values of each characters).

No.	Characters
C1	Growth habit: herbaceous (0), arborescent (1), lianescent (2), shrubby (3), none (4)
C2	Node anatomy: unilacunar (0), bilacunar (1), trilacunar (2), multilacunar (3), none (4), pentalacunar (5)
C3	Branching: dichotomous (0), axillary (1), monopodial (2), sympodial (3), pseudomonopodial (4) trichotomous (5)
C4	Tunica-carpus: absent (0), present (1)
C5	Stem secondary growth: absent (0), present (1)
C6	Stele type: protostele (0), solenostele (1), dictyostele (2), polycyclostele (3), acyclostele (4), siphonostele (5), eustele (6), polystele (7), clepsydroid (8), arthrostele (9), atactostele (A), monostele (B), distele (C), tristele (D), actinostele (E)
C7	Wood type: pycnoxylic (0), manoxylic (1), none (2)
C8	Cambium: unifacial (0), bifacial (1), none (2)
C9	Tracheid wall thickening: fimbrial (0), scalariform (1), annular (2), helical (3), none (4), pitting (5), reticulate (6)
C10	Long and short : absent (0), present (1)
C11	Primary xylem maturation: endarch (0), mesarch (1), exarch (2), centrarch (3)
C12	Conducting elements: only tracheids (0), vessels or vessel and tracheids (1), none (2)
C13	Xylem ray: uniseriate (0), multiseriate (1), none (2), biseriate (3)
C14	Vessel element perforation: all scalariform with many bars (>20) (0), all or most simple with few bars (<20) (1), all or most simple and scalariform with few bars (2), none (3)
C15	Intervessel pitting: scalariform (0), scalariform-opposite (1), opposite (2), opposite-alternate (3), alternate (4), none (5), with bordered pit (6), with simple pit (7)
C16	Vessel distribution: solitary (0), mostly solitary (1), with some clusters and some pairs and/or radial multiples (2), mostly radial multiples and clusters with few solitary (3), none (4)
C17	Vessel element in shoot: absent (0), present (1)
C18	Bordered pit: absent (0), present (1)
C19	Girdling leaf trace: absent (0), present (1)
C20	Types of rays: homogeneous (0), heterogeneous (1), paedomorphic (2), none (3)
C21	Leaf occurrence: absent (0), present (1)
C22	Leaf type: microphyll (0), megaphyll (1), none (2)
C23	Heterophylly: absent (0), present (1)

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- C24 Arrangement of lateral appendages: alternate opposite (0), whorled helical (1), decussate (2), none (3), 4-rank (4)
- C25 Leaf organization: simple (0), compound (1), none (2)
- C26 Ensiform lamina: absent (0), present (1)
- C27 Stipule: absent (0), present (1)
- C28 Venation: pinnate (0), actinodromous pinnate but with basal concentration of laterals parallel (1), dichotomous other palmate (2), one-veined (3), none (4)
- C29 Secondary veins: brochidodromous (0), craspedodromous (1), semicraspedocromous (2), camptodromous (3), none (4)
- C30 Leaf margin: smooth (0), serrate (1), none (2), dissected lobate (3),
- C31 Leaf/pinna shape: lobate (0), lingular (1), wedge-shaped (2), linear (3), dissected lanceolate (4), fan-like (5), strap-like (6), scale-like (7), oboval (8), none (9), needle-like(A), bifid (B), orbicular (C), cordate-based (D), peltate (E), tubular (F), teret (G)
- C32 Midrib: absent (0), present (1)
- C33 Vein reticulation: absent (0), present (1)
- C34 Stomata occurrence: hypostomatic (0), hyperstomatic (1), amphistomatic (2), on branch (3), none (4), on sporangia (5)
- C35 Stomata type: anomocytic (0), paracytic (1), tetracytic (2), dicyclic (3), laterocytic (4), encyclocytic (5), desmocytic (6), diacytic (7), pericytic (8), polocytic (9), hexacytic (A), anisocytic (B), parallelocytic (C), heliocytic (D), axillocytic (E), none (F)
- C36 Heterospory: absent (0), present (1)
- C37 Gender: bisexual (0), monoecious (1), dioecious (2), none (3), androdioecious (4), polygamomonoecious (5), polygamodioecious (6), gynomonoecious (7), gynodioecious (8), andromonoecious (9)
- C38 Siphonogamy:absent (0), present (1)
- C39 Reproductive and vegetaive organ : intermixing (0), separated (1), none (2),
- C40 Mega- and microsporangia arrangement: proximal (0), segregated (1), none (2),
- C41 Reproductive parts concentrated to the distal: absent (0), present (1)
- C42 Reproductive organ (flower/cone) base: sessile (0), pedicellate (1), none (2)
- C43 Reproductive organ peripheral foliar appendage merism: numerous and helical (0), pentamerous (1), tetramerous (2), few and variable (3), none (4), trimerous (5), hexamerous (6)
- C44 Reproductive organ 1st cycle peripheral foliar appendage connation: absent (0), present (1), none (2)
- C45 Reproductive organ 2nd cycle peripheral foliar appendage connation: absent (0), present (1), none (2)
- C46 Petal clawed: absent (0), present (1), none (2)
- C47 Hypanthium:absent (0), present (1)
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- C48 Nectary : absent (0), abaxial (1), gynoecial (2), surface (3), disc peripheral (4), foliar (5), appendage other position and roecial (6), extrafloral (7), perigonal (8), stylar (9), base stigmatic (A)
- C49 Microsporangia grouping: synangiate (0), distinct (1)
- C50 microsporangium arrangement: connate (0), free (1), none (2)
- C51 Heterostyly: absent (0), present (1), none (2)
- C52 Anther orientation: introrse (0), latrorse (1), extrorse (2), none (3)
- C53 Anther type: tetrasporangiate (0), bisporangiate (1), none (2), trisporangiate (3), unisporangiate (4), multisporgiate (5)
- C54 Microsporangium insertion: basifixed (0), dorsifixed (1), ventrifixed (2)
- C55 Microsporangia position relative to support structure: absent adaxial (0), abaxial (1), marginal (2), helical (3), terminal (4), peripheral (5), between bracts (6)
- C56 Microsporangia opening: longitudinal slit (0), valve pore (1), none (2), flap oblique slit (3), horizontal slit (4), apical slit (5), helical slit (6), decay radial slit (7)
- C57 Saccate pollen: bisaccate (0), monosaccate (1), none (2), pseudosaccate (3), tetrasaccate (4), trisaccate (5),
- C58 Microspore grouping: monad (0), dyad (1), tetrad (2), polyad (3)
- C59 Microspore size: > 20 um (0), < 20 um (1)
- C60 Tectum: absent (0), present (1)
- C61 Sculpture: reticulate (0), striate (1), clavate (2), rugulate (3), spinulose/scabrate (4), vermiform psilate (5), verrucate (6), foveolate (7), none (8), echinate (9), granular fossulate (A), rugose baculate (B), gemmate (C)
- C62 Tectal perforations: semitectate (0), tectate (1), perforate (2), imperforate (3), none (4), atectate (5),
- C63 Columellae :absent (0), present (1)
- C64 Number of ovule-enclosing unit (carpel/cupule) per reproductive organ: >5 (0), 5 (1), 4 (2), 2 (3), 1 (4), 1-5 (5), none (6),
- C65 Gynoecium positioning: superiort (0), only extreme baset (1), inferior basalt (2), half inferiort (3), mostly to completely inferiort (4), nonet (5)
- C66 Ovule-enclosing unit (carpel) stipitation: absent (0), present (1)
- C67 Ovule-enclosing unit (carpel) connation: distinct base of ovaries (0), connate ovaries (1), completely connate and base of styles (2), may be connate ovaries and styles completely connate (3), none (4),
- C68 Ovule-enclosing unit distal projection (style) position: eccentric (0), peak of ovary (1), intercalated to each other (2), absent terminal (3), decurrent (4), gynobasic (5)
- C69 Non-nucellar pollen receiving part (stigma) position: decurrent (0), ventral (1), apical (2), branched (3), none (4)
- C70 Arrangement of megasporangium complex (placentation): marginal axile-apical (0), axile-basal parietal (1),free (2), central (3), none (4), terminal peripheral adaxial (5), abaxial basal apical laminar (6),
- C71 Pendulous ovules: absent (0), present (1)
- C72 Number of megasporangium complexes per unit (carpel/cupule): many (>10) (0), few and variable (1-10) (1), one two (2), one per gynoecium (with more than one carpel/cupule) (3), none (4)
-

C73	Number of megasporangia surrounding layers (integument): two (0), one (1), none (2)
C74	Megasporangium complex orientation: orthotropous (0), anatropous (1), campylotropous (2), none amphitropous inverted (3),
C75	Fruit type: follicle or septicidal capsule (0), loculicidal capsule (1), nut or samaroid nutlet (achene) (2), fleshy (berry) (3), schizocarp (4), none (5), achene (6), samara (7), drupe (8), aggregate (9), silique (A), utricle (B), caryopsis (C), pome (D)
C76	Spermatozoid: absent (0), present (1)
C77	Number of functional megasporangia per megasporangium: one (0), more none (1)
C78	Megaspore tetrad: linear (0), tetrahedral (1), none (2),
C79	Megasporangium complex enclosed: absent (0), present (1)
C80	Megasporangia retained in on mother plant: absent (0), present (1)
C81	Megasporangium position relative to support structure: terminal abaxial (0), adaxial marginal lateral and isolated peripheral (1), none (2)
C82	Ovule-wrapping unit (cupule): absent (0), present (1)
C83	Ovule-wrapping unit (cupule) opening: distal adaxial (0), proximal abaxial (1), proximal none adaxial (2),
C84	Micropylar tube: absent (0), present (1)
C85	Pollination through pollen tube:absent (0), present (1)
C86	Archegonia in megaspore: absent (0), present (1), none (2)
C87	Double fertilization: absent (0), present (1)
C88	Endosperm: absent (0), present (1)
C89	Angiocarpy: absent (0), present (1)
C90	Vivipary: absent (0), present (1)
C91	Number of cotyledon: many (0), 4-3 (1), 1 (2), none (3)

Table S3. Taxa studied and GenBank accessions. A dash (-) indicates missing data, and the indicated sequences are from GenBank.

	<i>matK</i>	<i>rbcL</i>	ITS	<i>trnL</i>	<i>psbA-trnH</i>
Actinidiaceae	KP737312	KP737327	KP737354	JN102166	KP737342
Adoxaceae	EF490235	KM360613	U88194	AF366927	FJ395478
Aextoxicaceae	DQ182342	HE651123	AY590831	AY145362	-
Aizoaceae	JQ844150	AJ235778	AJ582944	KF132800	KF132892
Alangiaceae	FJ644649	DQ340449	KP092580	JN102141	JF321228
Alismataceae	AB040179	HQ901563	DQ339086	GQ244545	KC584951
Alseuosmiaceae	AJ429378	X87377	EU331124	AJ430965	-
Altingiaceae	AF015650	JX944788	GU576669	DQ352220	KP095965
Amoryllidaceae	JX464550	JX903147	AY280349	JX464362	KC704237
Amborellaceae	DQ185522	L12628	-	AY145324	-
Aquifoliaceae	AF542607	KX897006	AH007153	FR849986	KU198261
Araceae	AY034184	KM360996	KJ400913	AM933296	KC584957
Araliaceae	AB087999	U50250	KF727964	AF366930	KX347019
Araucariaceae	AM920149	U96471	-	-	FJ17352
Basellaceae	JQ844148	MF135428	KY968898	-	MF143716
Berberidaceae	JQ172882	KR075627	KC575606	FJ626558	JQ172934
Betulaceae	AY372021	KC482102	-	DQ860529	KP095389
Brassicaceae	AB354274	AY167979	GQ202247	AF451575	GQ184349
Brunelliaceae	EF135512	FJ707536	AY935891	AF299181	KJ426624
Bruniaceae	AY490949	L14391	AY494012	GQ984070	-
Buxaceae	LN877447	MF349741	AF245412	LN877711	AB331298
Cactaceae	HM041657	KT164772	AY181566	HM041236	KT222807
Campanulaceae	EU713264	AJ419698	KC013706	GQ984060	-
Caprifoliaceae	GQ997392	GQ997430	JQ780992	HM228560	GU135313
Caryophyllaceae	KU722867	M77699	KU722881	JN589634	GU070803
Celastraceae	EU002170	EU002277	EU002149	HQ393763	GQ998178
Cephalotaxaceae	AF457108	AF456387	JF976114	EF660619	EF660701
Cercidiphyllaceae	AB490203	L11673	AF147756	AB445242	AB445234
Chloranthaceae	AF543733	AF332097	D29787	AY145334	KP159335
Clethraceae	MF350258	L12609	KU350161	AJ430871	MF348393
Combretaceae	GU135057	FJ381811	KT279737	LC054306	KP319003
Connaraceae	EU002174	L29493	AY935892	KC428477	KX248193
Cornaceae	EU002175	EU002276	AY152522	AY254238	JF321206
Crassulaceae	AF115647	JX848453	AB088618	KX510105	KP159333
Crossosomataceae	DQ443456	DQ443456	DQ307116	DQ307148	KX999391
Cucurbitaceae	DQ536662	L21937	KC922448	HM597017	JQ007373
Cunoniaceae	JX517913	JX572494	AF521290	AF299156	-

Cupressaceae	AB023999	L25756	AY916904	JF514857	JF514865
Cycadaceae	AF143440	AB917042	KC508028	HG316537	KP117157
Cyclanthaceae	KT205206	KT205272	JN016949	KJ681523	KT205225
Cyperaceae	KX036931	AM999811	AF168838	AJ295759	KR735884
Davidsoniaceae	AY935930	AF206759	-	KC428488	KM895252
Dilleniaceae	GQ997143	FJ860350	AY096030	KF953925	KT452064
<i>Encephalartos</i>	GQ203845	AF394361	KX130213	-	KX152014
<i>Ephedra</i>	KP788852	FJ958029	FJ958007	KT033390	-
Ericaceae	U61316	L12625	AF382730	AF271699	MF348522
Erythropalaceae	DQ790197	DQ790161	DQ790230	EF464487	-
Escalloniaceae	AJ429365	AJ419694	U42544	AJ430952	KC355696
Eucommiaceae	AF345323	L01917	HQ384682	-	KX346918
Eucryphiaceae	EU002176	L01918	-	KF594405	KM895039
Euphorbiaceae	LK021494	AY794915	AY918198	AY794734	GU135374
Eupomatiaceae	DQ401341	DQ861790	AF469771	DQ861842	KU564673
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Fabaceae	AF203597	KM025243	AF156675	AY651848	GU396719
Fagaceae	FJ185050	KF418893	-	AF344182	-
Fouquieriaceae	EU628508	AY725861	AH007888	AJ430876	JF321292
Garryaceae	KT738340	KT740821	JN234737	JN234724	KT739195
Geraniaceae	KJ916373	KJ916495	DQ525074	AJ884716	KP963310
<i>Ginkgo</i>	AF279806	JQ512538	JQ279501	AY145323	AF223226
<i>Gnetum</i>	AY449621	U72819	AY449558	AY296493	AY849369
Gomortegaceae	-	AF206773	AF289846	-	AF129053
Gunneraceae	EU002179	EU002279	AF517101	AM397168	GQ998323
Gyrostemonaceae	FJ212199	L22440	AF070971	FJ212281	-
Hamaelidaceae	AF013046	KC737393	AF094551	DQ352357	KC737342
Hamamelidaceae	AF248617	AY263940	AF015654	GU576826	GU576755
Hydatellaceae	JQ284136	JQ284248	JQ284173	-	-
Hydrangeaceae	GU217324	JF308660	GU983035	JN226776	GU217324
Hydrocharitaceae	AB088781	AB088810	JN578091	-	-
Illiciaceae	DQ185524	DQ182334	AF163734	AY145325	-
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Iteaceae	EF456732	L11188	AY231368	-	AY138110
Juglandaceae	HE966942	KF418920	HM049898	AY231167	HE966671
Juncaceae	AY973527	L12681	KR082780	AY344156	HQ181837
Lauraceae	KU564571	KU564795	HG315591	KX674308	KU564671
Linaceae	JX661951	FJ169596	KX147539	FJ160887	GQ845215
Loasaceae	KY286710	U17876	KY286627	KY286979	JF321277
Loganiaceae	KJ815653	Z68826	DQ358879	AJ430910	-

Lythraceae	GU228449	L10223	-	AY905482	JQ730675
Magnoliaceae	AY00900	AY008933	EU593549	AY305819	HM236892
Melastomataceae	KP093302	GQ436728	KY798014	GQ265885	JF708230
Monimiaceae	AJ247183	AF040664	GU177689	AF129041	AF129068
Myricaceae	KF419021	KF418924	KP092762	DQ501450	KP095418
Myrothamnaceae	AM396507	AF060707	AF094555	AM397169	EU213839
Myrtaceae	AF368206	AB537496	-	HQ287716	KP142183
Najadaceae	HM240463	U03731	KT596618	KT596674	AB331276
Nepenthaceae	AF315891	L01936	AB675865	JX042575	MF348377
Neuradaceae	-	U06814	KJ004316	-	-
Nitrariaceae	-	DQ267158	DQ267176	DQ267166	KP087763
Nymphaeaceae	DQ185527	LC219121	JF805747	AF543729	KC525065
Nyssaceae	JF308675	JF308651	EU734443	EU734496	JF321237
Ochnaceae	KF263283	KF263405	KF263218	HQ599792	-
Olacaceae	GQ997871	GQ997898	DQ333869	DQ340620	GQ997883
Onagraceae	HM851006	EU255778	GU176556	GU176588	-
Orchidaceae	AF263677	AF074211	AY273748	AY273651	FJ460374
Oxalidaceae	EU002186	EU002282	EU436875	JN639556	GQ998541
Papaveraceae	KM364817	U86629	-	AY328253	-
Parnassiaceae	JF954971	JN105081	JF811045	DQ860575	JF802315
Penaeaceae	AY151582	AY151706	AM235864	-	AY151675
Penthoraceae	KC988293	AF190431	KC988286	X71987	DQ006173
Philydraceae	EU499296	AY298834	-	AJ387741	-
Phytolaccaceae	AY042631	FJ860398	KU377334	KM261955	MF143636
Picramniaceae	-	AF127025	-	-	KJ426870
Pinaceae	EF440492	EF440570	-	EF440530	FJ493294
Piperaceae	DQ882215	EF591363	KF924100	EU519779	KM055199
Pittosporaceae	DQ133794	HM850262	HM116994	AJ430960	KM895297
Platanaceae	EU642711	AF081073	AY706029	AY145358	KP402512
Poaceae	KM487287	AY836162	-	JX456355	HQ894425
Podocarpaceae	AF228112	AF249648	AB023989	EF660630	JN041002
Polemoniaceae	L34205	KX397893	AF167227	EF433257	KJ686557
Portulacaceae	EU834751	M62568	JF508549	-	MF143649
Primulaceae	HQ535964	HQ619773	-	KM198463	-
Proteaceae	AY823204	JX571862	-	AF482140	-
Ranunculaceae	EU827661	DQ099444	FJ424225	KP900425	KY235737
Rhamnaceae	GQ434248	KP121449	DQ146573	KR083150	HG765028
Rhizophoraceae	JX661962	JX664070	AF130332	AY947404	JX663300
Rhoipteleaceae	U92852	AF017687	AF303800	AY147081	KF201474
Rosaceae	DQ860466	JQ391365	JQ392451	DQ863238	JQ390723

Rubiaceae	KJ815700	FJ493349	-	KJ815420	MF348541
Sabiaceae	HM755905	HM755932	KM092335	KP900465	HM755920
Sapindaceae	KP675825	FN599461	KP675785	JN102157	KJ687156
Sarraceniaceae	JQ619005	KR819588	DQ098117	AJ430886	MF348369
Saxifragaceae	KC737243	KC737395	KC004032	JN102287	JF708213
Scrophulariaceae	KR424749	EF544598	EF363673	DQ856494	KR424763
Solanaceae	EF537313	AF397102	KP006659	EU603443	EF537224
Staphyleaceae	EU002189	EU002285	KR349376	KX999498	KX999401
Symplocaceae	AF380108	AY725865	MF171080	AF534682	EU769795
Taccaceae	AY973837	JF944589	JF978861	JN850578	JN047324
Taxodiaceae	AB030115	JQ512531	AB023983	AY727216	JQ512286
Tetracarpaeaceae	L34154	L11207	EF178790	-	-
Theaceae	-	AF380058	MF171105	HM100596	HM100528
Thymelaeaceae	KU244186	GQ436619	KX024773	GU736358	KU244056
Trapaceae	KX526694	L10226	FM887019	AY905491	-
Trochodendraceae	AF543751	GQ998840	AF192799	AY145360	GQ998829
Tropaeolaceae	FM179931	L14706	JN115053	AB043665	-
Turneraceae	JX661965	DQ123398	DQ521285	JQ723403	JX663303
Ulmaceae	KC539623	KC539693	KC539589	KC539738	-
Velloziaceae	JX286710	AY149358	JN016957	AF293095	JN017061
Vochysiaceae	GQ982128	AM235665	DQ787415	-	KX249560
<i>Welwitschia</i>	AF280996	AF394335	U50740	AY513733	AY849370
Winteraceae	EU669474	EU669518	AY526318	EU669556	FJ539202
<i>Zamia</i>	GQ203859	JQ770263	AJ287364	-	JQ770199

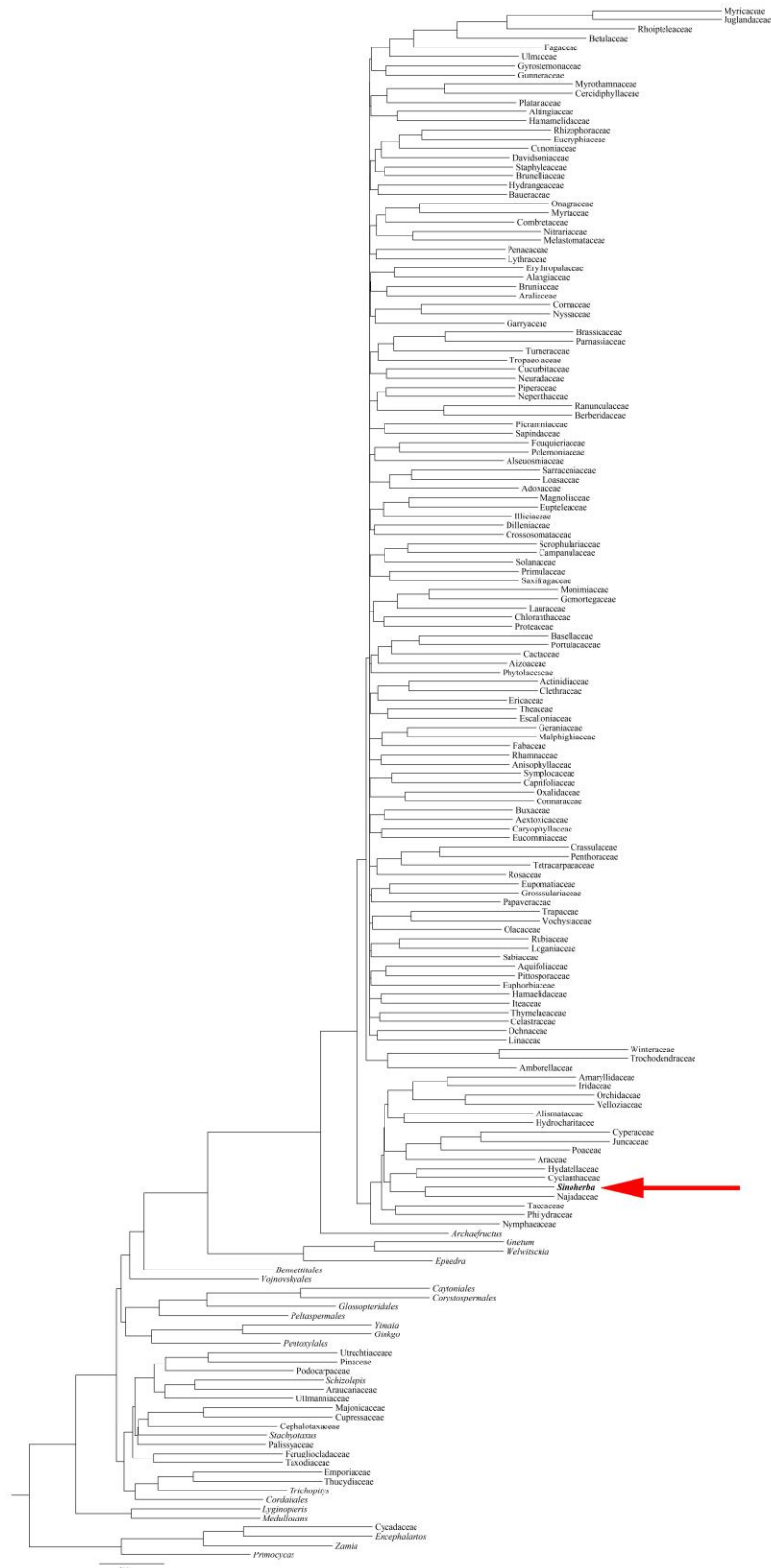


Figure S1. Phylogenetic relationships of the morphological characteristic score information. The numbers near the nodes are bootstrap percentages. “*” indicates that the node is 100% supported. “←” indicates the phylogenetic position of *Sinoherba*.



Figure S2. Phylogenetic relationships based on DNA sequence (*rbcL*, *matK*, *trnL-F*, *psbA-trnH* and ITS) and morphological characteristic score information of *Sinoherba*. The numbers near the nodes are bootstrap percentages. “*” indicates that the node is 100% supported. “←” indicates the phylogenetic position of *Sinoherba*.