

Supplementary Information includes:

Supplementary Fig. 1 Outcrop of in-situ stems of *Guangdedendron micrum* from the Upper Devonian of Guangde, Anhui, China.

Supplementary Fig. 2 Transverse sections of vascular cylinders in the stem of *Guangdedendron micrum* from the Upper Devonian of Guangde, Anhui, China.

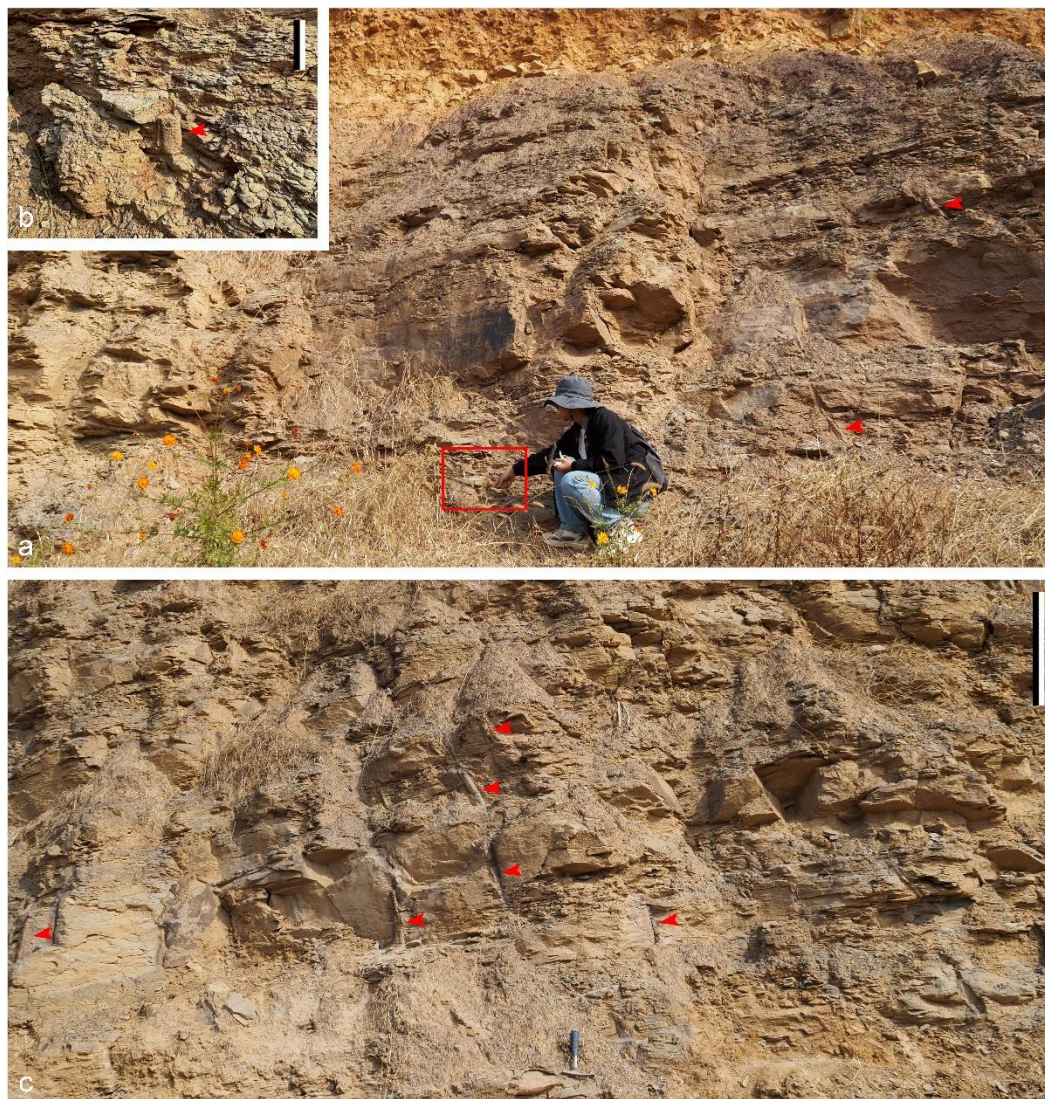
Supplementary Fig. 3 Lycopsid phylogeny derived from parsimony and Bayesian analyses (excluding the anatomical characters of *Guangdedendron*).

Supplementary Table 1 Distribution of characters used in the phylogenetic analyses.

Supplementary Text 1 Data matrix (tnt format) of Parsimony analysis.

Supplementary Text 2 Data matrix (nexus format) of Bayesian analysis.

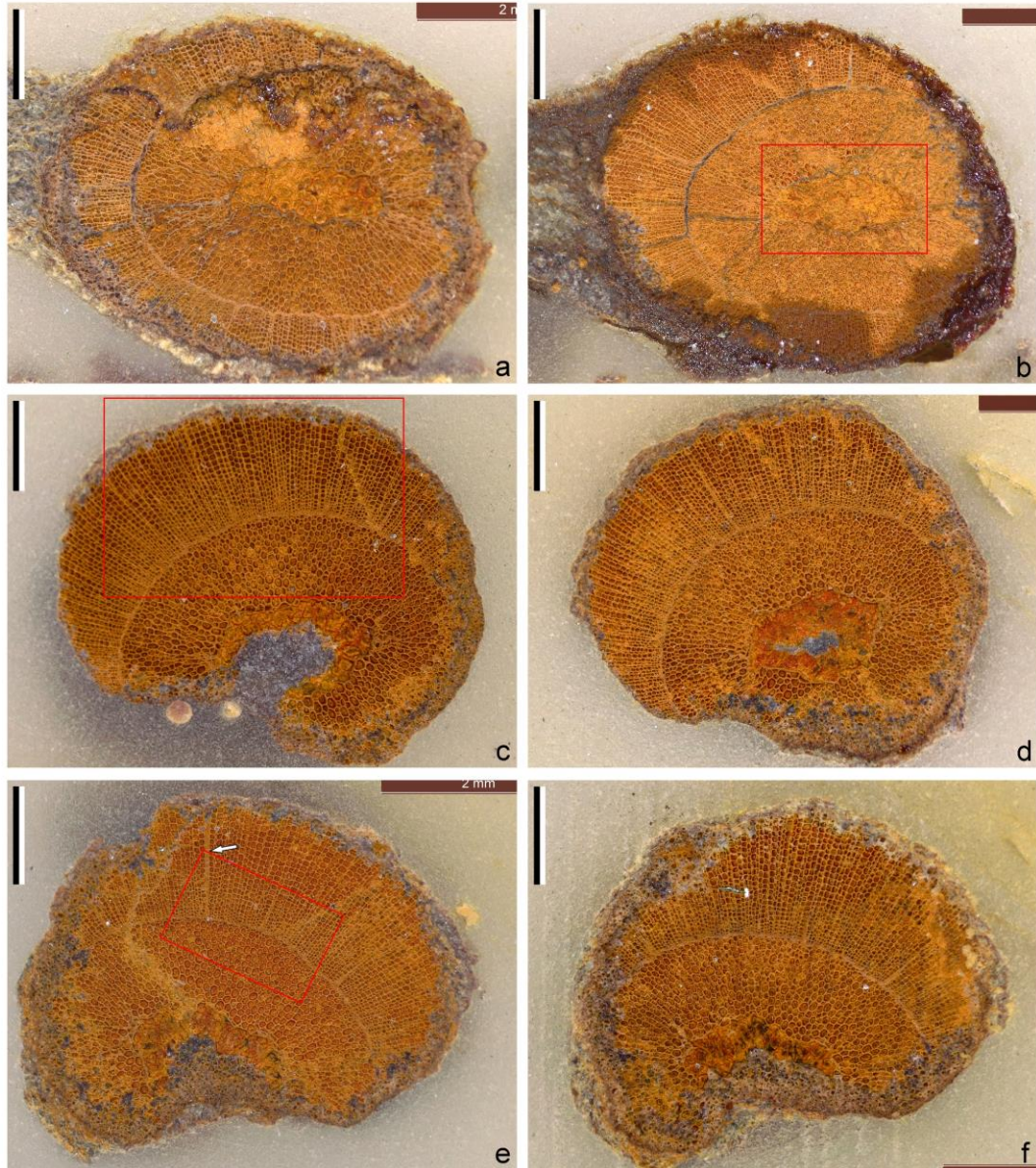
Supplementary Text 3 Supplementary references.



Supplementary Fig. 1 Outcrop of in-situ stems of *Guangdedendron micrum* from the Upper Devonian of Guangde, Anhui, China.

a, c. Different parts of the same outcrop showing in-situ stems (arrows).

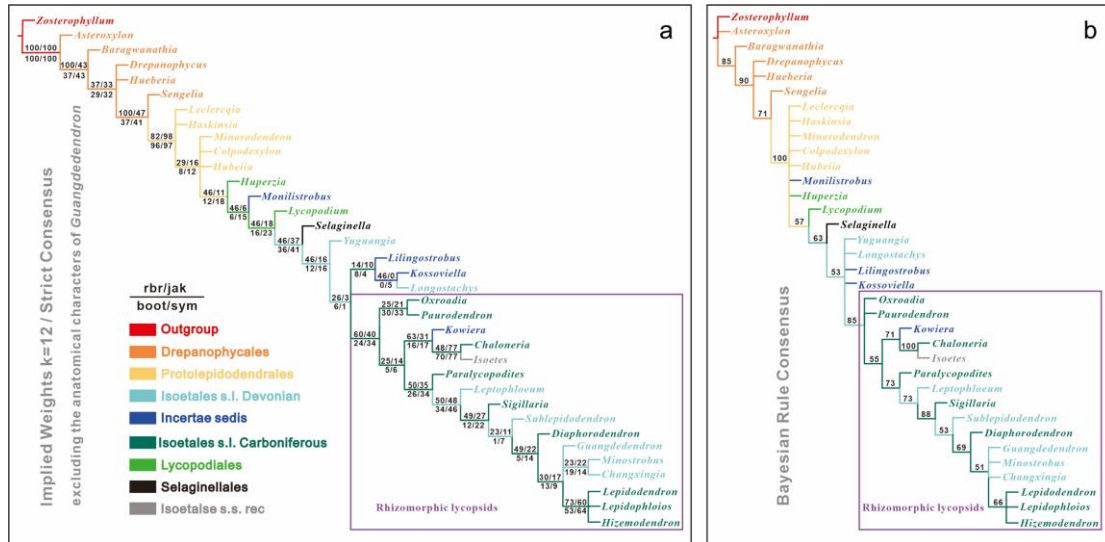
b. Enlargement of a (rectangle) showing the in-situ stem with limonitized vascular bundles.



Supplementary Fig. 2 Transverse sections of vascular cylinders in the stem of *Guangdedendron micrum* from the Upper Devonian of Guangde, Anhui, China. Scale bars: a–f, 1 mm.

a, b. Pith tissues with lumina filled in the center of the vascular cylinder.

c–f. Vascular cylinder showing well-preserved primary and secondary xylem tracheids.



Supplementary Fig. 3 Lycopsid phylogeny derived from parsimony and Bayesian analyses (excluding the anatomical characters of *Guangdedendron*).

a. Strict consensus trees ($k = 12$) based on the implied weights analysis of our dataset. The tree length = 128; consistency index (CI) = 0.484; retention index (RI) = 0.841. Different colors indicate orders as defined in previous studies. rbr, relative-bremer. jak, jackknifing. boot, bootstrap. sym, symmetric resampling.

b. Lycopsid phylogeny derived from the Bayesian analysis. Different colors indicate orders as defined in previous studies, and numbers on branches represent posterior probability values.

Supplementary Table 1. Distribution of characters used in the phylogenetic analyses.

N°	Characters
1	Growth habit: 0=unipolar growth; 1=bipolar growth.
2	Aerial axes: 0=branched; 1=unbranched.
3,4	Branching type: 00=lack; 10=isotomous; 11=K-branch; 12=lateral.
5	Centralized rooting system: 0=absent; 1=present.
6,7	Rhizomorph: 00=lack; 10= repeatedly dichotomized root; 11= cormose rhizomorph; 12= stigmaria rhizomorph.
8	Stele: 0=protostele; 1=actinostele; 2=plectostele.
9	Xylem strand structure: 0=solid; 1=medullated.
10	Ridges of protoxylem: 0=indistinguishable; 1=distinguishable.
11	Secondary xylem in stem: 0=absent; 1=present.
12	Scalariform thickening tracheid: 0=absent; 1=present.
13,14	Material between tracheid thickenings: 00=lack; 10=pitlet sheet; 11=Williamson's striation.
15	Cortex tissue: 0=two-zoned; 1=three-zoned.
16	Leaf cushions: 0=absent; 1=present.
17,18	Shape of leaf bases/cushions: 00=lack; 10=more or less circular; 11=longitudinally elongated; 12= radially elongated.
19,20	Leaf vasculature: 00=lack; 10=partial; 11=full.
21,22	Leaf shape: 00=lack; 10=simple; 11=forked.
23	Ligule: 0=absent; 1=present.
24,25	Ligule position: 00=lack; 10=superficial; 11=in pit.
26	Sporophyll: 0=absent; 1=present.
27,28	Sporophyll shape: 00=lack; 10=isomorph; 11=heteromorph.
29,30	Sporophyll distribution: 00=lack; 10=loosely dispersed on stem; 11=aggregated in strobilus.
31	Heterospory: 0=absent; 1=present.
32	Fertile structure: 0=intercalary; 1=terminal.
33,34	Strobilus: 00=lack; 10=bisporangiate; 11=monosporangiate.
35,36	Strobilus shape: 00=lack; 10=simple; 11=forked.
37,38	Sporophyll modification: 00=lack; 10=more or less unmodified; 11= horizontal pedicel and upturned lamina.
39,40	Megasporophyll–sporangium complexes: 00=lack; 10=absent; 11=present.
41,42	Alations of megasporophyll pedicel: 00=lack; 10=absent; 11=short, horizontal; 12=short, suberect; 13=long, erect
43,44	Sporangium attachment: 00=lack; 10=stalked; 11=unstaked or attached by a pad or subarchesporial tissue.
45	Sporangium shape: 0=flattened; 1=more or less spherical; 2=radially elongated.
46,47	Megaspores per megasporangium: 00=lack; 10=more than four; 11=four; 12=one functional megaspore and three abortive megaspores.
48,49	Gula: 00=lack; 10=absent; 11=present.
50,51	Equatorial ornamentation (megaspores): 00=lack; 10=absent; 11=present.
52,53	Equatorial ornamentation (Microspores): 00=lack; 10=absent; 11=present.

[illegible]


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135
136  begin mrbayes;
137  lset rates=gamma;
138  mcmc ngen=3000000 samplefreq=1000;
139  sump burninfrac=0.25;
140  sumt burninfrac=0.25;
141  end;
```

Supplementary Text 3. Supplementary references.

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