

**S1. List of taxa included in the disparity analysis and the phylogenetic analysis, with main references.**

Taxa in bold are included in the phylogenetic analysis; taxa also indicated by \* are included only in the phylogenetic analysis and not in the disparity analysis. Three unpublished arborescent taxa were included on the basis that they showed additional anatomical diversity. <sup>1</sup> *Callixylon* trunk from the Late Devonian of Morocco showing large sclerotic nests in pith; <sup>2</sup> Axis from the late Tournaisian of Algeria, previously figured in Galtier (1988), and Galtier & Meyer-Berthaud (2006); <sup>3</sup> Trunk from the late Viséan of Australia. All these specimens and corresponding slides are currently kept in the Paleobotanical collections, Service des Collections, Université Montpellier II, France, under the specimen numbers 600/2/3, JC874 and YB1-2.

		<b>Main reference</b>
		<b><i>Psilophyton</i>*</b> Banks et al., 1975
<b>Progymnosperms</b>	Aneurophytales	<b><i>Rellimia thomsonii</i></b> --- <b><i>Tetraxylopteris schmidtii</i></b> <i>Proteokalon petryi</i> <i>Triloboxylon arnoldii</i> Dannenhoffer & Bonamo, 2003; Dannenhoffer et al., 2007. Beck, 1957. Scheckler & Banks, 1971. Stein & Beck, 1983.
	Archaeopteridales	<i>Callixylon brownii</i> <i>Callixylon erianum</i> <i>Callixylon huronensis</i> <i>Callixylon newberry</i> <i>Callixylon trifilievii</i> <b><i>Callixylon zaleskyi</i></b> <i>Callixylon sp.</i> <i>Eddyia sullivanensis</i> Hoskin & Cross, 1951. Arnold, 1930. Chitaley & Cai, 2001. Arnold, 1931. Lemoigne et al., 1983. Arnold, 1930. Meyer-Berthaud, unpublished data <sup>1</sup> . Beck, 1967.
	Protopityales	<b><i>Protopitys buchiana</i></b> <i>P. scotica</i> <i>Protopitys sp.</i> Scott, 1923; Galtier et al., 1998. Walton, 1957. Decombeix et al., 2005.
<b>Spermatophytes</b>	Elkinsiales	<b><i>Elkinsia polymorpha</i></b> Serbet & Rothwell, 1992.
	Buteoxylales	<i>Buteoxylon gordonianum</i> --- <i>Triradioxylon primaevum</i> Barnard & Long, 1973; Matten et al., 1980. Barnard & Long, 1975.
	Lyginopteridales	<b><i>Laceyia hibernica</i></b> <i>Tristichia longii</i> <i>Tristichia triplos</i> <i>Tristichia ovensii</i> <i>Tetrastichia bupatides</i> <b><i>Lyginopteris oldhamia</i></b> <i>Lyginopteris royalii</i> <i>Lyginopitys puechcapelensis</i> <i>Trivena arkansana</i> <i>Heterangium grievii</i> May & Matten, 1983. Galtier, 1977. Galtier & Meyer-Berthaud, 1996. Long, 1961. Gordon, 1938. Jongmans, 1930. Tomescu et al., 2001. Galtier, 1970 Dunn et al., 2003b. Scott, 1917.
	Calamopityales	<i>Bostonia perplexa</i> <i>Calamopitys americana</i> <b><i>Calamopitys annularis</i></b> <i>Calamopitys embergeri</i> <i>Calamopitys eurameriana</i> <i>Calamopitys kentuckiensis</i> <i>Calamopitys saturnii</i> <i>Calamopitys schweitzeri</i> <i>Calamopitys solmsii</i> <i>Diichnia kentuckiensis</i> <i>Triichnia meyenii</i> <i>Stenomyelon bifasciculare</i> <i>Stenomyelon primaevum</i> <b><i>Stenomyelon tuedianum</i></b> Stein & Beck, 1992. Galtier & Beck, 1995. Galtier & Meyer-Berthaud, 1989. Galtier, 1970. Galtier & Beck, 1995. Galtier & Beck, 1995. Galtier & Meyer-Berthaud, 1989. Galtier et al., 1993. Galtier & Meyer-Berthaud, 1989. Beck et al., 1992. Galtier & Beck, 1992. Meyer-Berthaud, 1984. Meyer-Berthaud & Stein, 1995. Meyer-Berthaud & Stein, 1995.
	Medullosales	<i>Quaestora amplexa</i> <b><i>Medullosa steinii</i></b> Mapes & Rothwell 1980. Dunn et al., 2003a.
	Callistophytales	<b><i>Callistophyton poroxyloides</i>*</b> Rothwell, 1981
Incertae sedis	<i>Aporoxyton primaevum</i> Unger, 1856; Decombeix et al., 2005.	

(putative arborescent seed plants)	<i>Archaeopitys eastmanii</i> <b><i>Bilignea solida</i></b> <i>Bilignea resinosa</i> <i>Cauloxylon ambiguum</i> <b><i>Endoxylon zonatum</i></b> <i>Eristophyton beinertianum</i> <b><i>Eristophyton waltonii</i></b> <i>Eristophyton fasciculare</i> <i>Eristophyton feistii</i> JC874 <b><i>Faironia difasciculata</i></b> <i>Megalomyelon myriodesmon</i> <i>Megaloxylon wheelareae</i> <i>Pycnoxylon leptodesmon</i> <i>Pitus antiqua</i> <b><i>Pitus dayi</i></b> <i>Pitus withamii</i> <i>Pitus primaeva</i> <i>Stanwoodia kirktonense</i> YB1-2	Scott & Jeffrey, 1914. Scott, 1924. Scott, 1924. Cribbs, 1939. Scott, 1924; Lacey, 1953. Scott, 1902. Lacey, 1953; Galtier & Scott, 1990. Scott, 1902. Decombeix et al., 2008. Galtier, unpublished data <sup>2</sup> Decombeix et al., 2006. Cribbs, 1940. Mapes, 1985. Cribbs, 1938. Gordon, 1935. Gordon, 1935. Gordon, 1935. Gordon, 1935. Gordon, 1935. Galtier & Scott, 1991. Decombeix, unpublished data <sup>3</sup>
Cordaitales & conifers	<b><i>Cordaixylon iowanensis</i>*</b> <b><i>Mesoxylon priapii</i>*</b> <b><i>Thucydia mahoningensis</i>*</b>	Rothwell & Warner, 1984. Trivett & Rothwell, 1985. Hernandez-Castillo et al., 2001.

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## S2. Character list and matrix for the analysis of vegetative body disparity

1. Bilateral symmetry of ultimate appendages. 0: no, 1: yes.
2. Primary vascular architecture of stems. 0: protostelic with one central strand of protoxylem producing the others; 1: eustelic with few large strands of primary xylem; 2: eustelic with numerous small strands of primary xylem.
3. Polystele 0: absent, 1: present.
4. Pith anatomy. 0: no pith; 1: parenchyma only; 2: parenchyma and sclerotic nests; 3: short tracheids.
5. Location of primary xylem. 0: in contact with secondary xylem; 1: separated from secondary xylem by few layers of cells; 2: medullary strands present.
6. Primary xylem maturation. 0: mesarch; 1: mesarch to endarch at nodes; 2: endarch, 3: exarch to mesarch.
7. Emission of traces. 0: radial; 1: tangential.
8. Vascular traces. 0: single; 1: multiple trace emitted from the division of a single strand, 2: multiple trace emitted from the division of two or more strands at a same level, 3: multiple trace emitted from the division of two or more strands at different levels.
9. Organotaxis. 0: spiral or alternate; 1: some opposite
10. internode. 0: short<1 cm, 1: medium; 2: long (>10 cm).
11. Ratio of metaxylem tracheid diameter to secondary xylem tracheid diameter. 0: about 1; 1: > 1.
12. Secondary xylem pitting. 0: not separated in groups; 1: in groups.
12. Pitting. 0: araucarioid; 1: other.
14. Ray width. 0: uni ou biseriate; 1: multiseriate.
15. Ray height. 0:low (<10 cells); 1: medium (10 to 50 cells); 2:high (>50 cells).

Rellimia	000000001100011	CalamopitysKen	110100000110012
Tetraxylopteris	000000001100001	CalamopitysSat	110000010110012
Proteokalon	100000001000001	CalamopitysSch	110100010200012
Triloboxylon	100000000000001	CalamopitysSol	110100010110002
CallixylonBrw	120100000001001	Diichnia	110100020110012
CallixylonEri	120100000001001	Triichnia	110100010110012
CallixylonHur	120100000001001	StenomBif	110000010110012
CallixylonNew	120110000001011	StenomyelonPri	110000000110012
CallixylonTrif	120100000001001	StenomyelonTue	110000000110012
CallixylonZal	120100000001001	Quaestora	110000031210012
CallixylonSp	120200000001001	MedullosaStei	111100030210012
Eddya	110100000001001	Aporoxylon	120100100000001
ProtopitysBuc	110102101100100	Archaeopitys	1201200000000011
ProtopitysSco	110102101100100	BiligneaSol	120301100000100
ProtopitysSp	110102101100100	BiligneaRes	120301100000000
Elkinsia	100000000100011	Cauloxylon	1202111200000011
Buteoxylon	110000000110011	Endoxylon	120102100000000
Triradioxylon	110000000100011	EristophytonBei	120201100000000
Laceyia	110000000100011	EristophytonWal	1202111000000011
TristichiaLon	110000000100011	EristophytonFas	1201111000000011
TristiachiaTrip	110000000100011	EristophytonFei	1201011000000011
TristiachiaOve	110000000100001	JC874	1202101000000011
Tetrastichia	100000000100002	Faironia	1201100200000011
LyginopterisOld	110200100000012	Megalomyelon	1201100200000011
LyginopterisRoy	110200100100012	Megaloxylon	1203001000000011
Lyginopitys	1201100000000011	Pycnoxylon	1202111200000001
Trivena	110100000100012	PitusAnt	1201201000000011
Heterangium	110003100010012	PitusDay	1201201000000011
Bostonia	111000000110011	PitusWit	1201201000000011
CalamopitysAme	110000000110012	PitusPri	1201201000000011
CalamopitysAnn	110000010110012	Stanwoodia	120000101000000
CalamopitysEmb	110000000110012	YB1-2	1201101200000011
CalamopitysEur	110100000110012		

### **S3. Characters list and matrix for the phylogenetic analysis.**

#### **Reproduction (2)**

##### **1. Life cycle : (0) homosporous, (1) heterosporous**

Character 1 of Rothwell & Serbet (1994) and of Hilton & Bateman (2006), 59 of Hammond (2004).

##### **2. Ovule/seed (0) absent (1), present**

Character 60 of Hilton & Bateman (2006).

#### **General morphology (3)**

##### **3. Branching (0) apical, (1) axillary, one bud, (2) axillary, several buds**

Character 4 of Rothwell & Serbet (1994) and of Hilton & Bateman (2006). Branching is apical in progymnosperms. It is axillary with one (e.g., *Lyginopteris*) or several (e.g., *Mesoxylon*) buds in all the spermatophytes for which this character is documented.

##### **4. Organotaxis : (0) spiral or alternate (1) some opposite**

Modified from characters 5 of Rothwell & Serbet (1994), 4 of Hammond (2004) and 6 of Hilton & Bateman (2006).

##### **5. Bifacial cambium (0) absent; (1) present**

Character 39 of Hammond (2004). Excluded by Rothwell & Serbet (1994) on the basis that it is a synapomorphy of lignophytes.

#### **Primary vascular system (8)**

##### **6. Stele (0) protostele, (1) parenchymatous protostele and eustele.**

Character 16 of Rothwell & Serbet (1994). Hilton & Bateman (2006) proposed to distinguish between three states (protostele, parenchymatous protostele and eustele) based on the different types of stele described by Galtier (1988). We chose not to make this distinction, which does not affect the results for the list of taxa analysed here.

##### **7. Stele shape (0) lobed/polygonal, (1) elliptical/circular**

New character. According to some authors (e.g., Stein, 1993) the shape of the stele reflects hormonal fluxes from lateral organs.

##### **8. Ratio between stele diameter and total diameter of stem (0) 1 :10 to 1 :5, (1) >1 :5**

New character. This ratio is > 1:5 for taxa such as the Buteoxylales and Lyginopteridales and comprised between 1 :5 and 1 :10 in Calamopityales (Galtier, 1988).

##### **9. Protoxylem architecture: (0) one sympodium, (1) several sympodia.**

Character 14 of Rothwell & Serbet (1994), and 17 of Hilton & Bateman (2006).

##### **10. Size of primary xylem strands in eusteles : (0) large, (1) small**

New character. The size of primary xylem strands is highly variable in Devonian and Mississippian lignophytes.

##### **11. Number of primary xylem strands (0) few, (1) numerous**

New character.

##### **12. Maturation (0) mesarch, (1) endarch becoming mesarch at nodes, (2) endarch**

Modified from character 16 of Doyle & Donoghue (1996), 15 of Rothwell & Serbet (1994), and 21 of Hilton & Bateman (2006), to include the fact that in *Eristophyton* and *Biliginea* the maturation is different at the nodes.

##### **13. Ratio between metaxylem tracheid diameter and secondary xylem tracheid diameter (0) about 1, (1) MX>X2**

New character. Allows comparing the size of primary and secondary xylem tracheids without quantitative bias. In most lignophytes the ratio is about 1, however the calamopityales have much larger metaxylem tracheids (Galtier, 1988).

#### **Secondary xylem (6)**

Some characters are from the IAWA List of Microscopic Features for Softwood Identification (2004); some of the quantitative categories from the IAWA list have been modified to adapt them to the larger range of variation observed in fossil wood.

##### **14. Tangential pitting of secondary xylem tracheids (0) similar to radial pitting, (1) reduced or absent**

New character. The secondary xylem tracheids of aneurophytales displays similar pitting on all walls. In other Devonian or Mississippian taxa for which this character is documented, tangential pitting is either reduced or absent.

##### **15. Radial pitting (0) continuous, (1) unpitted areas**

New character. Groups of pits separated by unpitted areas are a characteristic of the archaeopteridalean progymnosperms *Callixylon*, *Actinoxylon* and *Eddyia* (Beck et Wight, 1988).

##### **16. Radial pitting (0) araucarioid, (1) uniseriate**

New character. Early lignophytes typically have araucarioid pitting on the radial walls of their secondary xylem tracheids. A few taxa such as *Biligneia resinosa* have a single row of pitting, a character also present in some conifers.

**17. Ray tracheids (0) absent or rare, (1) abundant**

New character. Modified from characters 79 and 80 of the IAWA list. Ray tracheids are present in some aneurophytalean and archaeopteridalean progymnosperms, some Mississippian seed plants and some conifers.

**18. Ray width (cell number): (0) uni to biseriate, (1) multiseriate**

Character 22 of Doyle & Donoghue (1986) and 28 of Hilton & Bateman (2006). Non-included character 1 of Rothwell & Serbet (1994).

**19. Ray height (cell number): (0) low (<30 cells), (1) medium, (2) high (>90 cells)**

New character. From characters 102-105 of IAWA list. The IAWA list distinguish 4 categories of ray height 1-4 cells, 5-15, 15-30 and more than 30. This has been modified to accommodate the fact that higher rays are frequent in some Mississippian taxa.

**Phloem and cortex (4)**

**20. Secondary phloem(0) with fibers, (1) without fibers**

New character [excluded by Doyle & Donoghue (1986) on the basis that it is poorly documented].

Aneurophytalean progymnosperms have a complex phloem with fibers. Beck & Wight (1988) describe a more simple phloem for *Archaeopteris* but the study of a new specimen (Meyer-Berthaud et Scheckler, 2000) shows an anatomy comparable to the aneurophytes. Among the Mississippian taxa *Eristophyton*, *Pitus*, *Stanwoodia* and *Biligneia* have a secondary phloem with fibers while *Calamopitys* phloem has no fibers.

**21. *Sparganum/ Dictyoxylo*n outer cortex (0) present, (1) absent**

Character 30 of Hilton & Bateman (2006). A *Sparganum* outer cortex is documented in aneurophytalean progymnosperms and *Elkinsia*. Among the Mississippian taxa a distinction has been traditionally made between the outer cortex of the Lyginopteridales ('*Dictyoxylo*n') formed by alternating bands of sclerenchyma and parenchyma, and the outer cortex of the Calamopityales ('*Sparganum*') in which these bands anastomose. However, there is apparently a range of variation between these two types of outer cortex. Since the distinction between the two types is not always clear we followed Hilton & Bateman (2006) and grouped them in a single character.

**22. Periderm (0) absent, (1) present**

New character. Rothwell & Serbet (1994) excluded the character based on their hypothesis that it is a synapomorphy of lignophytes and thus of no use in their analysis ('production of periderm by a phellogen, excluded character 5).

**23. Sclerotic nests in cortex (0) absent, (1) present**

New character. Sclerotic nests are present in the cortex of aneurophytalean progymnosperms and some spermatophytes (Galtier, 1988)

**Leaves/ultimate appendages (9)**

**24. Symmetry of ultimate appendages (0) tridimensionnal, (1) planate**

New character. Ultimate appendages (i.e. appendages with determinate growth) are tridimensionnal in some aneurophytalean progymnosperms such as *Tetraxylopteris* or *Rellimia*. They are planate in *Triloboxylon*, *Proteaokalon*, the archaeopteridalean progymnosperms and the spermatophytes.

**25. Lamina (0) absent, (1) present**

New character. Ultimate appendages of the aneurophytalean progymnosperms can be planate but are not webbed like the archaeopteridalean progymnosperms and the spermatophytes.

**26. Leaves (0) compound pinate (1) linear**

Simplified from character 7 of Rothwell & Serbet (1994) and of Hilton & Bateman (2006) due to the limited amount of taxa analysed here.

**27. Leaf trace produced by (0) radial division of axial strand, (1) tangential division of axial strand**

New character. Excluded by Doyle & Donoghue (1986) on the basis that it was poorly documented. According to Namboodiri & Beck (1968) this is an important character of early lignophyte evolution. Archaeopteridalean progymnosperms or Calamopityales are examples of groups in which the division is in radial plane. It is tangential in most of the arborescent taxa of the Mississippian.

**28. Vascular traces to a single lateral organ (0) one, (1) multiple**

This character and the next one are a modification of character 17 of Rothwell & Serbet (1994) and 20 of Hilton & Bateman (2006) to account for the diversity observed in the chosen taxa. Multiple vascular traces to a single organ are documented in some Calamopityales, Medullosales, some Mississippian arborescent taxa (e.g. *Megalomyelon*), *Faironia*, and some cordaites.

**29. Number of axial strands contributing to the vascularisation of a single lateral organ: (0) one, (1) two or more, adjacent, at a same level (2) two or more, non-adjacent, at a same level, (3) two or more on a significant vertical distance**

This character and the previous one are a modification of character 17 of Rothwell & Serbet (1994) and 20 of Hilton & Bateman (2006) to account for the diversity observed in the chosen taxa. Double or triple vascular traces to a same organ can be the result of the division of a single axial strand (e.g. *Calamopitys*), or of two adjacent axial strands that can be adjacent (e.g. *Diichnia*) or non-adjacent (e.g. *Faironia*).

**30. Primary xylem in the base of the petiole (0) one strand, (1) a few strands (2-6), (2) numerous strands**  
New character. Not included by Doyle on the basis that it was poorly documented.

**31. Bifurcated rachis (0) absent, (1) present**

Character 8 of Doyle & Donoghue (1986) and of Hilton & Bateman (2006).

**32. Deciduous leaves**

New character.

**Excluded characters.**

Rhythmic growth: (0) no rings or false rings only, (1) growth rings.

Sclerotic nests in pith: (0) absent, (1) present

Location of primary xylem: (0) in contact with secondary xylem, (1) separated from secondary xylem by parenchyma

Medullary strands: (0) absent, (1) present

"Scalariform" pitting on secondary xylem tracheids: (0) absent, (1) present.

	1	10	20	30
<i>Psilophyton</i>	000000	0?0??	???	???
<i>Tetraxylopteris</i>	000110100	00000010111110	0000000000	0000000000
<i>Callixylon</i>	1000110?	11100110101??	1?1110000000	0000000000
<i>Elkinsia</i>	11?010100?	001000001?	10111100?	1110
<i>Lyginopteris</i>	11101100100001000	111011111100010		
<i>Medullosa</i>	1110110?	100011000120110111113210		
<i>Callistophyton</i>	11101100100001000120110111100110			
<i>Mesoxylon</i>	1120110011100100000111110100001			
<i>Cordaixylon</i>	1110110011120100000011?110100001			
<i>Thucidya</i>	1110110011??	01010000010110???	01	
<i>Bilignea</i>	???	01100111101010001?	1?11?1001?	1
<i>Pitus</i>	???	0110011100100011111111100111		
<i>Eristophyton</i>	???	0110011110100001???	1?111100111	
<i>Stenomyelon</i>	???	010111???	01100012010111?00?2?0	
<i>Calamopitys</i>	??	10111110001100012010111?0112?0		
<i>Laceyia</i>	???	010100???	00100001?101111000010	
<i>Protopytis</i>	1?	00110?10020101000???	???	0???
<i>Faironia</i>	???	0110011100100011110111?	0121?0	
<i>Endoxylon</i>	???	0110010020100000???	1???	100???

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