Supplemental Material for: Megan Nibbelink, Alexandru M.F. Tomescu. 2022. "Exploring Zosterophyll Relationships within a More Broadly Sampled Character Space: A Focus on Anatomy." International Journal of Plant Sciences 183(6). DOI: 10.1086/720384.

Appendix 1. Taxa included in phylogenetic analyses (in alphabetical order) and literature used to score phylogenetic characters for each taxon.

Crenaticaulis verruculosus Banks & Davis 1969
Age: mid- to late Emsian
Rock unit: Battery Point Formation, Québec (Canada)
Preservation: Permineralizations, compressions
Source: Banks and Davis 1969

Deheubarthia splendens Edwards et al. 1989
Age: upper Lochkovian
Rock unit: Lower Old Red Sandstone, South Wales (UK)
Preservation: Permineralizations, compressions
Source: Edwards et al. 1989

Discalis longistipa Hao 1989
Age: Pragian
Rock unit: Posongchong Formation, Yunnan (China)
Preservation: Compressions
Source: Hao 1989

Euthursophyton hamperbachense Mustafa 1978
Age: late Eifelian
Rock unit: Brandenberg-Schichten, Germany
Preservation: Compressions, permineralizations
Source: Mustafa 1978

Gosslingia breconensis Heard 1927
Age: Siegenian-Emsian
Rock unit: Lower Old Red Sandstone, South Wales (UK)
Preservation: Permineralizations, compressions
Source: Kenrick and Edwards 1988a, Edwards 1970

Huia gracilis Wang and Hao 2001
Age: Pragian - early Emsian
Rock unit: Xujiachong Formation, Yunnan (China)
Preservation: Compressions
Source: Wang and Hao 2001

Konioria andrychoviensis Zdebska 1982
Age: Emsian
Rock unit: borehole samples from unnamed unit, Poland
Preservation: Permineralizations, compressions
Source: Zdebska 1982

Margophyton goldschmidtii Zakharova 1981

Age: Pragian - Emsian
Rock unit: Pridorozhnaya strata and others, Russia
Preservation: Permineralizations, compressions
Source: Zakharova 1981

Nothia aphylla Kerp et al. 2001
Age: Pragian
Rock unit: Rhynie Chert, Scotland
Preservation: Permineralizations
Source: El-Saadawy and Lacey 1979, Kerp et al. 2001

Psilophyton dawsonii Banks et al. 1975
Age: Mid- to late Emsian
Rock unit: Battery Point Formation, Québec (Canada)
Preservation: Permineralizations, compressions
Source: Banks et al. 1975

Renalia heuberi Gensel 1976
Age: Mid- to late Emsian
Rock unit: Battery Point Formation, Québec (Canada)
Preservation: Compressions
Source: Gensel 1976

Sawdonia (Ensivalia) deblondii Gensel and Berry 2016
Age: Pragian
Rock unit: Formation d'Acoz, Belgium
Preservation: Compressions, permineralizations
Source: Gerrienne 1996, Gensel and Berry 2016

Sawdonia ornata Hueber 1971
Age: Pragian - Emsian
Rock unit: Lower Old Red Sandstone, South Wales (UK); Battery Point Formation, Québec (Canada)
Preservation: Permineralizations, compressions
Source: Rayner 1983, Gensel and Berry 2016

Sengelia radicans Matsunaga and Tomescu 2017
Age: late Lochkovian - Pragian
Rock unit: Beartooth Butte Formation, Wyoming (USA)
Preservation: Compressions
Source: Matsunaga and Tomescu 2017

Serrulacaulis furcatus Hueber and Banks 1979
Age: late Givetian - early Frasnian (late Givetian age based on Berry and Gensel 2019 for the Campo Chico Formation)

Rock unit: Onenota Shale (Genesee Group) equivalent, New York (USA); Campo Chico Formation, Venezuela
Preservation: Compressions
Source: Hueber and Banks 1979, Berry and Edwards 1994

Stolbergia spiralis Fairon 1967
Age: Eifelian - Givetian
Rock unit: Vicht or Pepinster Formation, Belgium
Preservation: Permineralizations
Source: Fairon 1967

Thrinkophyton formosum Kenrick and Edwards 1988b
Age: Pragian - Emsian
Rock unit: Lower Old Red Sandstone, South Wales (UK)
Preservation: Permineralizations, compressions
Source: Kenrick and Edwards 1988b

Trichopherophyton teuchansii Lyon and Edwards 1991
Age: Pragian
Rock unit: Rhynie Chert, Scotland
Preservation: Permineralizations
Source: Lyon and Edwards 1991

Ventarura lyonii Powell et al. 2000
Age: Pragian
Rock unit: Rhynie Chert, Scotland
Preservation: Permineralizations
Source: Powell et al. 2000

Zosterophyllum fertile Leclercq 1942 [includes information from Edwards' (1969a) *Zosterophyllum* cf. *fertile*]
Age: Pragian - Emsian
Rock unit: Lower Old Red Sandstone, South Wales (UK)
Preservation: Permineralizations, compressions
Source: Edwards 1969a

Zosterophyllum llanoveranum Croft and Lang 1942
Age: Pragian - Emsian
Rock unit: Lower Old Red Sandstone, South Wales (UK)
Preservation: Permineralizations, compressions
Source: Edwards 1969b

Appendix 2. Phylogenetic characters. A – characters used in the "anatomy-only" analysis; M – characters used in the "morphology-only" analysis.

Vegetative anatomy

1. Stele type: 0 = haplostele; 1 = actinostele [A]

2. Pattern of primary xylem maturation: 0: exarch; 1: centrarch [A]

3. Distribution of protoxylem: 0: diffuse; 1: discrete bundles [A]

4. Scalariform patterning of secondary wall thickenings (metaxylem): 0 = absent; 1 = present [A]

5. Degradation-resistant layer in secondary wall thickenings: 0 = lining the thickenings; 1 = pervasive degradation resistance [A]

6. Inter-scalariform thickening tracheid wall patterning: 0 = *Gosslingia*-type tracheids; 1 = lycopsid-type tracheids (Williamson's striations); 2 = *Psilophyton*-type tracheids [A]

7. Stele shape: 0 = terete; 1 = elliptical; 2 = strap-shaped; 3 = lobed. This character refines the cross-sectional shape of haplosteles and is only redundant with C1 (state 1) for *Sengelia*, the only actinostelic taxon in the dataset [A]

8. Cortex histology: 0 = homogeneous; 1 = stratified. This character describes whether the entire thickness of the cortex consists of cells of the same type or of concentric layers each consisting of cells of different types [A]

9. Sclerified outer cortex: 0 = absent; 1 = present. This character applies to the presence of a sclerenchymatous layer in the cortex, beneath the epidermis, and is inapplicable for taxa in which C8 = 0 [A]

10. Sclerified outer cortex thickness: 0 = 'thin' proportional to axis thickness; 1 = 'thick' proportional to axis thickness. This character describes the relative thickness of the sclerified outer layer in the cortex and is inapplicable for taxa in which C9 = 0 or inapplicable [A]

11. Histologically distinct mid-cortical layer: 0 = absent; 1 = present. This character applies to concentric layers consisting of cells of a different type than re rest of the cortex, and located in-between the central vascular strand and the epidermis, at some distance from either of those [A]

12. Mid-cortical layer thickness: 0 = single cell layer; 1 = multiple cell layers. This character applies to layers of the type described above (C11) and is inapplicable for taxa in which C11 = 0 [A]

13. Epidermal cell size: 0 = cells of regular size (approximately the same size as adjacent cortical cells); 1 = large cells (larger than adjacent cortical cells); 2 = small cells (smaller than adjacent cortical cells) [A]

14. Cellular differentiation in the epidermis (other than stomata or trichomes): 0 = absent; 1 = present. This characters refers to cases in which some epidermal cells differ in size (or shape) from the majority of epidermal cells [A] [M]

15. Trichomes (hair-like extensions): 0 = absent; 1 = present [A] [M]

Vegetative morphology

16. Stout multicellular protrusions (more substantial than trichomes): 0 = absent; 1 = conical (spine-like); 2 = prismatic [A] [M]

17. Morphology of protrusions: 0 = monomorphic; 1 = dimorphic. This character is inapplicable for taxa in which C16 = 0 [M]

18. Tip of protrusions: 0 = sharp-tipped (spines); 1 = rounded tips; 2 = flat-tipped. This character is inapplicable for taxa in which C16 = 0 [M]

19. Wrinkled axis surface: 0 = absent; 1 = present [A] [M]

20. Leaves (i.e., vascularized appendages with regular taxis and adaxial-abaxial polarity): 0 = absent; 1 = present [A] [M]

21. Branching pattern of proximal plant axes: 0 = isotomous; 1 = pseudomonopodial. Characters 21 and 22 are hard to score with certainty, given the fragmentary nature of plant fossils. As a best approximation, we scored plant fragments that included terminal branches or bore sporangia as distal, and those lacking these indications of proximity to apical portions as proximal [M]

22. Branching pattern of distal plant axes: 0 = isotomous; 1 = pseudomonopodial [M]

23. Branch laterals run parallel to main axis: 0 = absent; 1 = present. This character refers to a branching pattern in which lateral branches acquire an orientation parallel to that of the main axis on a short distance from the branching point, which generates a Ч shape (or the shape of an upside-down “h”) [M]

24. K-branching (also known as H-branching): 0 = absent; 1 = present [M]

25. Subaxillary tubercles: 0 = absent; 1 = present [M]

26. Circinate tips: 0 = absent; 1 = present [A] [M]

Sporangial arrangement and morphology

27. Sporangial distribution: 0 = single; 1 = grouped (in discrete fertile zones); 2 = paired [A] [M]

28 Position of lateral sporangia: 0 = on more than one side of axis; 1 = only on one side of axis [A] [M]

29. Grouped sporangia: 0 = potentially intercalary fertile zone; 1 = terminal fertile zone. This character is inapplicable for taxa in which C27 = 0 or 2 [M]

30. Terminal fertile zone: 0 = lax terminal fertile zone (sporangia spaced out); 1 = compact terminal fertile zone, i.e., adjacent sporangia in contact with eaxch other (strobilus). This character is inapplicable for taxa in which C27 = 0 or 2 and C29 = 0 [M]

31. Sporangiotaxis: 0 = alternate; 1 = subopposite; 2 = opposite. This character is inapplicable for taxa in which C28 = 1 [M]

32. Ranks of sporangium files: 0 = one vertical rank; 1 = two vertical ranks; 2 = no ranks (may be helical) [A] [M]

33. Sporangium orientation: 0 = laterally oriented (dehiscence pointing away from the axis); 1 = apically oriented (sporangium proximo-distal axis oriented parallel with the axis and dehiscence pointing toward axis tip) ; 2 = adaxially recurved (sporangium dehiscence pointing toward the axis) [A] [M]

34. Sporangial stalk: 0 = absent (sessile sporangium); 1= short (stalk L:W $\leq$ 1); 2 = long (stalk L:W > 1) [A] [M]

35. Sporangium shape – proximo-distal: 0 = long (L:W > 1); 1 = short (L:W $\leq$ 1) [A] [M]

36. Sporangium shape – dorsi-ventral: 0 = thick (dorsi-ventral flattening absent); 1 = flat (sporangia dorsi-ventrally flattened) [A] [M]

37. Relative size of porangium valves: 0 = isovalvate; 1 = abaxial valve larger/deeper; 2 = adaxial valve larger/deeper [A] [M]

38. Sporangium dehiscence: 0 = distal line; 1 = lateral line ('*Huia*-type') [A] [M]

39. Sporangium valves thickened along line of dehiscence: 0: absent; 1: present [A] [M]

40. Protrusions on sporangia: 0 = absent; 1 = single-celled; 2 = multicellular [A] [M]

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Appendix 3. Phylogenetic matrix.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Psilophyton dawsonii	0	1	-	1	0	2	0	1	1	1	0	-	2	0	0	0	-	-	0	0
Renalia heuberi	0	?	?	1	?	?	0/1	?	0	-	?	?	?	?	0	0	-	-	0	0
Sengelia radicans	1	0	1	1	?	?	3	?	0	-	?	?	?	0	0	0	-	-	0	1
Crenaticaulis verruculosus	0	0	1	1	?	?	1	1	1	1	0	-	0	1	0	1	0	1	0	0
Deheubarthia splendens	0	0	?	1	0	0	1/2	1	1	0	0	-	0	1	0	1	0	0	0	0
Discalis longistipa	?	?	?	1	?	0	?	?	?	?	?	?	?	0	0	1	0	1/2	0	0
Euthursophyton hamperbachense	0	0	0	1	1	?	0/1	1	1	1	0	-	?	?	0	1	0	0	0	0
Gosslingia breconensis	0	0	?	1	0	0	1	1	1	0	0	-	0	1	0	0	-	-	0	0
Huia gracilis	0	?	?	1	0	0	1	?	?	?	?	?	?	1	0	0	-	-	0	0
Konioria andrychoviensis	0	0	0	1	?	?	0/1	1	1	0	0	-	?	?	0	1	1	0	0	0
Margophyton goldschmidtii	0	0	?	1	0	?	1	?	?	?	?	?	?	?	0	1	0	0	0	0
Nothia aphylla	0	?	?	0	?	-	0	0	0	-	0	-	0/1	1	0	0	-	-	1	0
Sawdonia deblondii	0	0	?	1	0	0	1	?	?	?	?	?	?	?	0	1	0	0	0	0
Sawdonia ornata	0	0	?	1	?	?	2	1	1	?	0	-	0	1	1	1	0	1	0	0
Serrulacaulis furcatus	?	?	?	1	0	0	?	?	?	?	?	?	?	1	0	2	0	0	0	0
Stolbergia spiralis	0	0	0	1	0	0	0	1	?	?	0	-	0	?	0	0	-	-	0	0
Thrinkophyton formosum	0	0	?	1	1	0	1	?	?	?	?	?	?	?	1	0	-	-	0	0
Trichopherophyton teuchansii	0	0	0	1	?	0	0	1	0	-	0	-	2	?	1	0	-	-	0	0
Ventarura lyonii	0	0	?	1	0	0	0	1	0	-	1	1	?	?	0	0	-	-	0	0
Zosterophyllum fertile	0	0	?	1	?	0	0	1	1	0	?	?	?	?	0	0	-	-	0	0
Zosterophyllum llanoveranum	0	0	?	1	?	?	0	1	1	1	0	-	?	?	0	0	-	-	0	0

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Appendix 3. Phylogenetic matrix (continued).

Character	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	39	39	40
Psilophyton dawsonii	0/1	0/1	0	0	0	0	2	-	-	-	-	-	1	2	0	0	-	1	0	0
Renalia heuberi	1	0	0	0	0	0	2	-	-	-	-	-	1	2	1	1	0	0	1	0
Sengelia radicans	-	-	-	1	0	0	1	0	0	-	0	2	1	0	1	?	0	0	?	0
Crenaticaulis verruculosus	0/1	?	0	0	1	1	1	0	0	-	1/2	1	1	1	1	0	1	0	?	0
Deheubarthia splendens	1	0	0	0	1	1	1	0	0	-	1/2	1	1	1	1	?	0	0	0	0
Discalis longistipa	?	?	?	1	0	1	1	0	1	0	0	2	1	2	1	1	0	0	1	2
Euthursophyton hamperbachense	1	0	0	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Gosslingia breconensis	1	0/1	0	0	1	1	1	0/1	0	-	-	0	0	1	1	1	0	0	1	0
Huia gracilis	?	0	1	1	1	0	1	0	1	0	0	2	2	2	0	0	0	1	0	0
Konioria andrychoviensis	?	0/1	0	0	0	1	0	1	-	-	-	-	?	1	1	1	0	0	0	1
Margophyton goldschmidtii	1	0	1	0	1	0	0	1	-	-	-	-	0	1	?	?	0	?	?	0
Nothia aphylla	1	0	0	0	0	0	1	0	1	0	0	-	2	2	1	0	0	0	0	0
Sawdonia deblondii	1	?	0	1	1	1	1	1	0	-	-	0	1	2	1	1	1	0	0	2
Sawdonia ornata	1	?	1	1	0	1	1	0	0	-	2	1	2	1	1	0	1	0	0	2
Serrulacaulis furcatus	?	1	0	?	0	1	1	1	0	-	0	1	0	1	1	1	0	0	1	0
Stolbergia spiralis	?	?	0	0	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Thrinkophyton formosum	1	0	0	0	1	1	1	0	0	-	2	1	1	1	1	1	0	0	1	0
Trichopherophyton teuchansii	?	?	?	?	0	1	?	?	?	?	?	?	1	0	1	1	1	0	0	1
Ventarura lyonii	0	0	?	?	0	0	1	?	1	1	?	?	0	0	1	1	0	0	1	0
Zosterophyllum fertile	0	0	0	0	0	1	1	0	1	1	0	1/2	1	2	0	1	?	0	1	0
Zosterophyllum llanoveranum	?	?	?	?	?	?	1	0/1	1	1	-	0/1	1	2	1	1	0	0	1	0

Appendix 4. Character scoring comments.

C21 and C22 (branching pattern of proximal vs distal parts of the plant) are hard to score with certainty, given the fragmentary nature of plant fossils. As a best approximation, we scored plant fragments that included terminal branches or bore sporangia as distal, and those lacking these indications of proximity to apical portions as proximal.

C24 (presence/absence of K-branching/H-branching): while scoring K-branching present represents a certainty, absence of K-branching can be scored with certainty only if a good number of specimens representing the proximal, rhizomatous portions of the plants are known. However, in some cases the proximal parts of a species may not be known, or it may be difficult to tell if the material available includes such parts (especially given the morphological simplicity of many early tracheophytes). In such cases, while we acknowledge the presence of uncertainty, our scoring approach was to consider the number of specimens known for a species. Thus, we scored K-branching absent, rather than unknown, in *Gosslingia breconensis*, *Deheubarthia splendens*, and *Thrinkophyton formosum*, based on the fact that good numbers of specimens are known for these species, as reported in the relevant literature (see Appendix 1). Under this scoring approach, our decision to score K-branching absent in *Konioria andrychoviensis* is less soundly supported, but we stand by it.

C29 (grouped sporangia): the presence of intercalary fertile zones is difficult to demonstrate with certainty given the fragmentary state of most plant fossil specimens. That is why state 0 accounts for potentially intercalary fertile zones and was scored in species where strobili are not known and fertile axes truncated distally do not show an acropetal pattern of decreasing sporangium sizes.

***Crenaticaulis verruculosus* –** Banks and Davis 1969
C3: In their description, Banks & Davis (1969) suspect that the protoxylem forms multiple discrete strands at the periphery of the primary xylem, although they recognize that the exact organization of the protoxylem cannot be ascertained unequivocally.
C3, 4: p. 444
C6: possibly similar to Williamson's striations (p. 444)
C9, 10: p. 442, fig 26 and p. 444
C13: p. 443
C14, 15***:*** p. 440, fig 13; p. 443
C21, 22: p. 444 only proximal portions available, scoring is polymorphic
C25, 28-30, 31, 32: p. 443
C31-32: p. 440, fig 6
C35, 36: p. 443
C37: p. 444

***Deheubarthia splendens* –** Edwards et al. 1989
C3: p. 315
C5: p. 306, fig 35
C4, 6: p. 316
C9, 10: p. 305-306 (hypodermis), fig 30-32 (2 cells thick)

C13: p. 306, fig 30-32; p. 301
C14, 15, 17: p. 298 fig 2, p. 302 fig 12, p. 304 fig 27; diagnosis 299
C21, 22: p. 299; p. 298, fig. 1
C26, 27: p. 298
C29: Table, p. 297
C30: Table, p. 296
C31: p. 307 (for 'present'), short assumed from picture (p. 298), reconstruction (p. 300)
C32, 33: p. 307 (also figs 1, 3, 7, 28)
C34: Table, p. 297
C35, 36: p. 304, fig 28

Discalis longistipa – Hao 1989
C6: p. 165 Plate IV, Fig. 11 and 12
C15, 16: p. 158
C17: p. 160
C21-24: p. 159, 160
C27, 28, 29: p. 166
C30: p. 161 plate 1; p. 166 fig 6
C31, 34: p. 159
C32, 33: p. 161 fig 4
C36, 37: p. 159

Gosslingia breconensis – Heard 1927; Croft and Lang 1942; Kenrick and Edwards 1988a; Edwards 1970
C1, 2: p. 98, 99 (Kenrick Edwards 1988a)
C4, 5: p. 100 (Kenrick Edwards 1988a)
C9: 'peripheral tissues' p.103; p. 99 fig 1 (Kenrick Edwards 1988a)
C13: p. 233 fig 26 (Edwards 1970)
C14, 15: p. 230 (Edwards 1970); Heard (1927) describes protuberances bearing trichomes, but Edwards (1970) does not find any trichomes associated with the protuberances. Variable size and shape noted, irregular surface discussed as being present in number of zosterophylls but good specific detail is lacking.
C28: sporangia seen in both 2 ranks and single ranked p.229 (Edwards 1970)
C30, 31: p. 230 fig 21, p. 231fig 54 (Edwards 1970)
C27-40: p.229-230 (Edwards 1970)
C38: p. 235, fig. 48 notes significant darkening of distal margin (Edwards 1970).
C41: thin cuticle on sporangia shows epidermal 'bumps'. Heard (1927) attributes as trichome bases, Edwards (1970) finds no trichomes. Scored "0" (absent) because no conspicuous (i.e., large protrusions) are present on the sporangia.

Huia gracilis – Wang and Hao 2001
C1: p. 166, fig 1; p. 161
C2: although authors claim centrarch maturation pattern, figure (p. 166 fig 1) is unconvincing. Left unscored.
C4: p. 166, plate 4
C5: p. 166, fig 5

C6: p. 158
C7: p. 161
C9-12: p. 166, fig 1
C14-19: p. 159
C21, 22: p. 159
C23: p. 158
C24, 25: p. 159
C26, 28: p. 158
C30: p. 160 fig 2, 5; p. 161
C31: p. 158
C32, 33: p. 160, plate 1
C34, 35: p. 164 fig 6
C37: p. 160, plate 1

***Konioria andrychoviensis* –** Zdebska 1982
C3: p. 253, fig 3
C4: p. 253, fig 7. Zdebska (1982) mentions and illustrates axis segments that yielded tracheids with alternate bordered pits; I did not score them as representing *Konioria*, as no other zosterophyll is known to possess bordered pits, so those specimens represent most likely a different taxon.
C10: p. 253, fig 3
C15, 17: p. 251, fig 1-3
C21, 22: p. 249, fig 1, 4; p. 252, text fig. 1; diagnosis p. 256
C22: p. 249, fig 4
C31-34, 37: p. 254

***Margophyton goldschmidtii* –** Zakharova 1981
C15-17: p. 115
C21, 22: appears pseudomonopodial throughout in reconstruction, diagnosis says ‘monopodially and dichotomously’; seems to have lateral appendages with isotomous branching (Plate XI, fig. 3 and 7)
C24: p. 115
C30: plate XI fig. 1
C31: reconstruction, plate 11
C34: plate XI fig. 1

***Nothia aphylla* –** El-Saadawy and Lacey 1979; Kerp et al. 2001
C1-3: Kerp et al. 2001, Figure 4.5 A-H; El-Saadawy and Lacey 1979, p. 132
C4-6: El-Saadawy and Lacey 1979, p. 132
C9: El-Saadawy and Lacey 1979, p. 132
C13: El-Saadawy and Lacey 1979, plate I, fig 3
C14: El-Saadawy and Lacey 1979, plate I, fig. 1
C21, 22: Kerp et al. 2001 fig 4.3, 4.4
C25: El-Saadawy and Lacey 1979, p. 123
C26, 29: El-Saadawy and Lacey 1979, fig 2; p. 128/9
C30: El-Saadawy and Lacey 1979, fig 2

C31: El-Saadawy and Lacey 1979, fig 2
C32, 33: El-Saadawy and Lacey 1979, fig 2; Plate 4
C34: El-Saadawy and Lacey 1979, Plate 4 fig. 1, 2, 11; fig 4
C35: El-Saadawy and Lacey 1979, Plate 4 fig. 1, 2, 11
C36: El-Saadawy and Lacey 1979, Plate 4 fig. 1-3

***Psilophyton dawsonii* –** Banks et al. 1975
C5: plate 19, figs 27 and 28
C13: p. 85
C14: p. 105
C21, 22: p. 87, 89

***Sawdonia deblondii* –** Gerrienne 1996
C21, 22: isotomous and anisotomous (polymorphic); unclear if any differentiation present between proximal and distal axis segments.

***Sawdonia ornata* –** Rayner 1983, Gensel et al. 1975
C4, 6: Rayner 1983, p. 85, fig. 4
C9, 10: Rayner 1983, p. 85
C13: unknown anatomically but because they are monomorphic, assume 'average'
C14: Rayner 1983, fig 3 - trichomes scored present based on the presence of "rosettes" of cells in the epidermis, arranged around a central cell with different type of cuticle. In most plants such cell rosettes in the epidermis are associated with trichome bases. Some cells isodiametric, some elongated.
C21, 22: Rayner 1983, p. 79-81
C16: Rayner 1983, fig 1d
C32-37: Rayner 1983, p. 90, fig 7

***Serrulacaulis furcatus* –** Berry and Edwards 1994, Hueber and Banks 1979
C4-6: Berry and Edwards 1994, Plate 2 p.148
C14: Berry and Edwards 1994, p.149
C15-17: Berry and Edwards 1994, Plate I, fig 1
C21, 22: p.145 Berry & Edwards 1994
C29: Hueber and Banks 1979 p.175
C30: Hueber and Banks 1979 plate III fig 6, text fig 1
C34: Hueber and Banks 1979 plate 3 fig 6, p. 169
C32, 33: Hueber and Banks 1979 plate III fig 6, text fig 1
C34-36: Hueber and Banks 1979 p.175

***Stolbergia spiralis* –** Fairon 1967
C12: histology of mid-cortical layer not described and difficult to assess due to preservation.
C21, 22: based on a single specimen, which may have had pseudomonopodial branching, if the appendage based don't represent sporangial attachment points

***Thrinkophyton formosum* –** Kenrick and Edwards 1988b
C14: p.100

C32, 33: figs 1-5 p.101

Trichopherophyton teuchansii – Lyon and Edwards 1991
C4, 6: p.326 fig I
C9, 13: p.326 fig F
C21, 22: p.101, fig 1
C26, 28: Powell et al 2000 p.341
C30-34: p.325
C35: p.326 fig B, G
C36: p.326 fig B, G
C37: p.326 fig B

***Ventarura lyonii* –** Powell et al 2000
C1, 2: p.335 fig A
C6: p.339
C12: p.337
C14-17: p.332
C21, 22: p.332 - only short fragments available, branching is +/- equal isotomous and infrequent
C26, 28: p.339 – only isolated sporangia found, but author believes most likely in strobili
C30: p.339
C31, 33, 35, 37: p.339
C29, 32, 36: p.341

Zosterophyllum fertile – Leclercq 1942; Edwards 1969a
C4: Edwards 1969a p.926
C29: Edwards 1969a p.294
C9, 10: Edwards 1969a p.925
C21, 22: Edwards 1969a p.924
C23: K-branching known in other species of *Zosterophyllum*, not observed in *Z.fertile*
C29: Edwards 1969a p.924
C31-34: Edwards 1969a p.928 fig 1a, b, c
C36: Edwards 1969a p.926

***Zosterophyllum llanoveranum* –** Croft and Lang 1942; Edwards 1969b
C2: Edwards 1969b p.202
C3: Edwards 1969b p.202
C4: Edwards 1969b p. 205
C9, 10: Edwards 1969b fig 13-15
C13: Edwards 1969b p.201
C14-18: Edwards 1969b fig 4, 24
C21, 22: Edwards 1969b p.201
C26, 28-37: p.202 fig 4, 20-26
C37: Edwards 1969b p.204

Appendix 5. Phylogenetic matrix - nexus file.

```
#NEXUS

BEGIN TAXA;
	TITLE Taxa;
	DIMENSIONS NTAX=21;
	TAXLABELS
		Psilophyton_dawsonii Renalia_heuberi Sengelia_radicans
Crenaticaulis_verruculosus Deheubarthia_splendens Discalis_longistipa
Ensivalia_deblondii Euthursophyton_hamperbachense Gosslingia_breconensis Huia_gracilis
Konioria_andrychoviensis Margophyton_goldschmidtii Nothia_aphylla Sawdonia_ornata
Serrulacaulis_furcatus Stolbergia_spiralis Thrinkophyton_formosum
Trichopherophyton_teuchansii Ventarura_lyonii Zosterophyllum_fertile
Zosterophyllum_llanoveranum
	;

END;


BEGIN CHARACTERS;
	TITLE  Character_Matrix;
	DIMENSIONS  NCHAR=40;
	FORMAT DATATYPE = STANDARD RESPECTCASE GAP = - MISSING = ? SYMBOLS = "  0 1 2
3";
	CHARSTATELABELS
		1 Stele_type,
		2 Pattern_of_primary_xylem_maturation,
		3 Distribution_of_protoxylem,
		4 Scalariform_pattern_of_secondary_thickenings,
		5 'Degradation-resistant layer in secondary wall thickenings',
		6 'Inter-scalariform thickening tracheid wall patterning',
		7 Stele_shape,
		8 Cortex_histology,
		9 Sclerified_outer_cortex,
		10 Sclerified_outer_cortex_thickness,
		11 'Distinct mid-cortical layer',
		12 'Mid-cortical layer thickness',
		13 Epidermis_cell_size,
		14 'Cellular differentiation in the epidermis (other than stomata or
trichomes)',
		15 Trichomes,
		16 Multicellular_protrusions,
		17 Morphology_of_multicellular_protrusions,
		18 Tip_of_multicellular_protrusions,
		19 Wrinkled_axis_surface,
		20 Leaves,
		21 Proximal_branching_pattern,
		22 Distal_branching_pattern,
		23 Branch_laterals_run_parallel_to_main_axis,
		24 'K-branching',
		25 Subaxillary_tubercles,
		26 Circinate_tips,
		27 Sporangial_distribution,
		28 Position_of_lateral_sporangia,
		29 Grouped_sporangia,
		30 Terminal_fertile_zone,
		31 Sporangiotaxis,
		32 Ranks_of_sporangium_files,
		33 Sporangium_orientation,
		34 Sporangial_stalk,
		35 'Proximo-distal sporangium shape',
```

```
            36 'Dorsi-ventral sporangium shape',
            37 Sporangium_valves,
            38 Sporangium_dehiscence,
            39 Dehiscence_rim_thickening,
            40 Protrusions_on_sporangia ;
      MATRIX
      Psilophyton_dawsonii           01-10201110-2000--00{0 1}{0 1}00002-----1200-100
      Renalia_heuberi                0??1??{0 1}?0-????00--001000002-----12110010
      Sengelia_radicans              1011??3?0-???000--01---100100-02101?00?0
      Crenaticaulis_verruculosus     0011??11110-01010100{0 1}?0011100-{1 2}1111010?0
      Deheubarthia_splendens         00?100{1 2}1100-0101000010001100-{1 2}1111?0000
      Discalis_longistipa            ???1?0????????0010{1 2}00???10110100212110012
      Sawdonia_deblondii            00?1001???????0100001?0111110--012111002
      Euthursophyton_hamperbachense  00011?{0 1}1110-??0100001000001?????????????
      Gosslingia_breconensis         00?10011100-0100--001{0 1}00111{0 1}0--001110010
      Huia_gracilis                  0??1001??????100--00?0111010100222000100
      Konioria_andrychoviensis       0001??{0 1}1100-??011000?{0 1}000101----?1110001
      Margophyton_goldschmidtii      00?10?1???????01000010101001----01??0??0
      Nothia_aphylla                 0??0?-000-0-{0 1}100--1010000010100-22100000
      Sawdonia_ornata                00?1??211?0-011101001?1101100-2121101002
      Serrulacaulis_furcatus         ???100???????1020000?10?01110-0101110010
      Stolbergia_spiralis            00010001??0-0?00--00??0000?????????????
      Thrinkophyton_formosum         00?1101???????10--00100011100-2111110010
      Trichopherophyton_teuchansii   0001?0010-0-2?10--00????01??????10111001
      Ventarura_lyonii               00?100010-11??00--0000??001?11??00110010
      Zosterophyllum_fertile         00?1?00110????00--0000000110110{1 2}1201?010
      Zosterophyllum_llanoveranum    00?1??01110-??00--00??????1{0 1}11-{0 1}12110010

;

END;
BEGIN ASSUMPTIONS;
      TYPESET * UNTITLED   =  unord:  1- 40;

END;

BEGIN MESQUITECHARMODELS;
      ProbModelSet * UNTITLED   =  'Mk1 (est.)':  1- 40;
END;

BEGIN NOTES;

      TEXT   CHARACTER = 1 STATE = 0 TEXT = haplostele;
      TEXT   CHARACTER = 1 STATE = 1 TEXT = actinostele;
      TEXT   CHARACTER = 1 STATE = 2 TEXT = plectostele;
      TEXT   CHARACTER = 2 STATE = 0 TEXT = exarch;
      TEXT   CHARACTER = 2 STATE = 1 TEXT = centrarch;
      TEXT   CHARACTER = 2 STATE = 2 TEXT = other;
      TEXT   CHARACTER = 3 STATE = 0 TEXT = diffuse;
      TEXT   CHARACTER = 3 STATE = 1 TEXT = discrete;
      TEXT   CHARACTER = 4 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 4 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 5 STATE = 0 TEXT = lining_the_thickenings;
      TEXT   CHARACTER = 5 STATE = 1 TEXT = pervasive_degredatin_resistance;
      TEXT   CHARACTER = 6 STATE = 0 TEXT = '(G-type)';
      TEXT   CHARACTER = 6 STATE = 1 TEXT = '(Lycopsid-type)';
      TEXT   CHARACTER = 7 STATE = 0 TEXT = terete;
      TEXT   CHARACTER = 7 STATE = 1 TEXT = elliptical;
      TEXT   CHARACTER = 7 STATE = 2 TEXT = 'strap-shaped';
      TEXT   CHARACTER = 7 STATE = 3 TEXT = lobed;
      TEXT   CHARACTER = 8 STATE = 0 TEXT = homogenous;
      TEXT   CHARACTER = 8 STATE = 1 TEXT = stratified;
      TEXT   CHARACTER = 9 STATE = 0 TEXT = absent;
```

```
      TEXT   CHARACTER = 9 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 10 STATE = 0 TEXT = thin_proportional_to_axis;
      TEXT   CHARACTER = 10 STATE = 1 TEXT = thick_proportional_to_axis;
      TEXT   CHARACTER = 11 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 11 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 12 STATE = 0 TEXT = single_cell_layer;
      TEXT   CHARACTER = 12 STATE = 1 TEXT = multiple_cell_layers;
      TEXT   CHARACTER = 13 STATE = 0 TEXT = '''regular'' cells, i.e., about as large
as adjacent cortical cells (in transverse section)';
      TEXT   CHARACTER = 13 STATE = 1 TEXT = 'large cells, i.e., significantly larger
than adjacent cortical cells (in transverse section)';
      TEXT   CHARACTER = 13 STATE = 2 TEXT = 'small cells i.e. smaller than adjacent
cortical cells (in transverse section)';
      TEXT   CHARACTER = 14 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 14 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 15 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 15 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 16 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 16 STATE = 1 TEXT = conical;
      TEXT   CHARACTER = 16 STATE = 2 TEXT = prismatic;
      TEXT   CHARACTER = 17 STATE = 0 TEXT = monomorphic;
      TEXT   CHARACTER = 17 STATE = 1 TEXT = dimorphic;
      TEXT   CHARACTER = 18 STATE = 0 TEXT = 'sharp-tipped';
      TEXT   CHARACTER = 18 STATE = 1 TEXT = 'round-tipped';
      TEXT   CHARACTER = 18 STATE = 2 TEXT = 'flat-tipped';
      TEXT   CHARACTER = 19 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 19 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 20 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 20 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 21 STATE = 0 TEXT = isotomous;
      TEXT   CHARACTER = 21 STATE = 1 TEXT = pseudomonopodial;
      TEXT   CHARACTER = 22 STATE = 0 TEXT = isotomous;
      TEXT   CHARACTER = 22 STATE = 1 TEXT = pseudomonopodial;
      TEXT   CHARACTER = 23 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 23 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 24 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 24 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 25 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 25 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 26 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 26 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 27 STATE = 0 TEXT = single;
      TEXT   CHARACTER = 27 STATE = 1 TEXT = grouped;
      TEXT   CHARACTER = 27 STATE = 2 TEXT = paired;
      TEXT   CHARACTER = 28 STATE = 0 TEXT = on_all_sides_of_axis;
      TEXT   CHARACTER = 28 STATE = 1 TEXT = only_on_one_side_of_axis;
      TEXT   CHARACTER = 29 STATE = 0 TEXT = potentially_intercalary_fertile_zone;
      TEXT   CHARACTER = 29 STATE = 1 TEXT = terminal_fertile_zone;
      TEXT   CHARACTER = 30 STATE = 0 TEXT = lax_terminal_fertile_zone;
      TEXT   CHARACTER = 30 STATE = 1 TEXT = 'compact terminal fertile zone
(strobilus)';
      TEXT   CHARACTER = 31 STATE = 0 TEXT = 'opposite/subopposite';
      TEXT   CHARACTER = 31 STATE = 1 TEXT = alternate;
      TEXT   CHARACTER = 32 STATE = 0 TEXT = one_vertical_rank;
      TEXT   CHARACTER = 32 STATE = 1 TEXT = two_vertical_ranks;
      TEXT   CHARACTER = 32 STATE = 2 TEXT = 'no vertical ranks (can be helical)';
      TEXT   CHARACTER = 33 STATE = 0 TEXT = 'laterally-oriented';
      TEXT   CHARACTER = 33 STATE = 1 TEXT = 'apically-oriented';
      TEXT   CHARACTER = 33 STATE = 2 TEXT = adaxially_curved;
      TEXT   CHARACTER = 34 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 34 STATE = 1 TEXT = 'short (L:W</= 1)';
      TEXT   CHARACTER = 34 STATE = 2 TEXT = 'long (L:W > 1)';
      TEXT   CHARACTER = 35 STATE = 0 TEXT = 'long (L:W > 1)';
```

```
      TEXT   CHARACTER = 35 STATE = 1 TEXT = 'short (L:W </= 1)';
      TEXT   CHARACTER = 36 STATE = 0 TEXT = '''fat'' (dorsi-ventral flattening
absent)';
      TEXT   CHARACTER = 36 STATE = 1 TEXT = '''flat'' (dorsi-ventral flattening
present)';
      TEXT   CHARACTER = 37 STATE = 0 TEXT = isovalvate;
      TEXT   CHARACTER = 37 STATE = 1 TEXT = abaxial_valve_larger;
      TEXT   CHARACTER = 37 STATE = 2 TEXT = adaxial_valve_larger;
      TEXT   CHARACTER = 38 STATE = 0 TEXT = distal;
      TEXT   CHARACTER = 38 STATE = 1 TEXT = 'lateral (''Huia-type'')';
      TEXT   CHARACTER = 39 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 39 STATE = 1 TEXT = present;
      TEXT   CHARACTER = 40 STATE = 0 TEXT = absent;
      TEXT   CHARACTER = 40 STATE = 1 TEXT = 'single-celled';
      TEXT   CHARACTER = 40 STATE = 2 TEXT = multicellular;
```

Appendix 6. Characters used in the phenetic analyses.

1. **Distribution of protoxylem:** 0 = diffuse; 1 = discrete
2. **Scalariform patterning of secondary wall thickenings:** 0 = absent; 1 = present
3. **Degradation resistant layer in secondary wall thickenings:** 0 = lining; 1 = pervasive
4. ***Gosslingia*-type tracheids:** 0 = absent; 1 = present
5. **Stele terete:** 0 = absent; 1 = present
6. **Stele elliptical:** 0 = absent; 1 = present
7. **Stele strap-shaped:** 0 = absent; 1 = present
8. **Cortex:** 0 = homogenous; 1 = stratified
9. **Sclerified outer cortex thickness**: 0 = 'thin' proportional to axis; 1 = 'thick' proportional to axis
10. **Distinct mid-cortical layer**: 0 = absent; 1 = present
11. **Epidermal cells approximately the same as adjacent cortical cells**: 0 = absent; 1 = present
12. **Epidermal cells larger than adjacent cortical cells:** 0 = absent; 1 = present
13. **Epidermal cells smaller than adjacent cortical cells:** 0 = absent; 1 = present
14. **Cellular differentiation in 'normal' epidermal cells:** 0 = absent; 1 = present
15. **Trichomes:** 0 = absent; 1 = present
16. **Conical multicellular protrusions:** 0 = absent; 1 = present
17. **Prismatic multicellular protrusions:** 0 = absent; 1 = present
18. **Morphology of protrusions:** 0 = monomorphic; 1 = dimorphic
19. **Sharp multicellular protrusion tips:** 0 = absent; 1 = present
20. **Rounded multicellular protrusion tips:** 0 = absent; 1 = present
21. **Flat multicellular protrusion tips:** 0 = absent; 1 = present
22. **Wrinkled axis surface:** 0 = absent; 1 = present
23. **Isotomous branching of proximal plant parts:** 0 = absent; 1 = present
24. **Pseudomonopodial branching of proximal plant parts:** 0 = absent; 1 = present
25. **Isotomous branching of distal plant parts:** 0 = absent; 1 = present
26. **Pseudomonopodial branching of distal plant parts:** 0 = absent; 1 = present
27. **Branch laterals run parallel to main axis:** 0 = absent; 1 = present
28. **K-branching:** 0 = absent; 1 = present
29. **Subaxillary tubercles:** 0 = absent; 1 = present
30. **Circinate tips:** 0 = absent; 1 = present
31. **Sporangia borne singly:** 0 = absent; 1 = present
32. **Sporangia grouped:** 0 = absent; 1 = present
33. **Sporangia paired:** 0 = absent; 1 = present
34. **Sporangia on more than one side of axis:** 0 = absent; 1 = present
35. **Sporangia on one side of axis:** 0 = absent; 1 = present
36. **Grouped sporangia:** 0 = potentially intercalary fertile zone; 1 = terminal fertile zone
37. **Terminal fertile zone (TFZ):** 0 = 'lax' TFZ; 1 = compact TFZ (strobilus)
38. **Sporangiotaxis alternate:** 0 = absent; 1 = present
39. **Sporangiotaxis subopposite:** 0 = absent; 1 = present
40. **Sporangiotaxis opposite:** 0 = absent; 1 = present
41. **Sporangia in one vertical rank:** 0 = absent; 1 = present
42. **Sporangia in two vertical ranks:** 0 = absent; 1 = present

43. **Sporangia in not in vertical ranks (may be helical):** 0 = absent; 1 = present
44. **Sporangia laterally oriented:** 0 = absent; 1 = present
45. **Sporangia apically oriented:** 0 = absent; 1 = present
46. **Sporangia adaxially recurved:** 0 = absent; 1 = present
47. **Sporangial stalk:** 0 = absent; 1 = present
48. **Sporangial stalk length:** 0 = short; 1 = long
49. **Sporangium shape – proximo-distal:** 0 = long; 1 = short
50. **Sporangium shape – dorsi-ventral:** 0 = fat; 1 = flat
51. **Sporangia isovalvate:** 0 = absent; 1 = present
52. **Sporangia with larger abaxial valve:** 0 = absent; 1 = present
53. **Sporangium dehiscence:** 0 = distal line; 1 = lateral line
54. **Dehiscence rim thickening:** 0 = absent; 1 = present
55. **Protrusions on sporangia absent:** 0 = no; 1 = yes
56. **Protrusions on sporangia single-celled:** 0 = absent; 1 = present
57. **Protrusions on sporangia multicellular:** 0 = absent; 1 = present

Supplemental Material for: Megan Nibbelink, Alexandru M.F. Tomescu. 2022. "Exploring Zosterophyll Relationships within a More Broadly Sampled Character Space: A Focus on Anatomy." International Journal of Plant Sciences 183(6). DOI: 10.1086/720384.

Appendix 7. Phenetic matrix for UPGMA analyses; for the NMDS analyses, "?" is converted to "0".

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Renalia hueberi	?	1	?	?	1	1	0	?	0	?	?	?	?	?	?	0	0	0	?	?	?	?	0	0	1	1
Crenaticaulis verruculosus	1	1	?	?	0	1	0	1	1	1	?	1	0	0	1	0	1	0	0	0	1	0	0	1	1	?
Deheubarthia splendens	?	1	0	1	0	1	1	1	1	0	?	1	0	0	1	0	1	0	0	1	0	0	0	0	1	1
Discalis longistipa	?	1	?	1	?	?	?	?	?	?	?	?	?	?	0	0	1	0	0	0	1	1	0	?	?	?
Sawdonia deblondii	?	1	0	1	0	1	0	?	?	?	?	?	?	?	?	0	1	0	0	1	0	0	0	0	1	?
Euthursophyton hamperbachense	0	1	1	?	1	1	0	1	1	1	?	?	?	?	?	0	1	0	0	1	0	0	0	0	1	1
Gosslingia breconensis	?	1	0	1	0	1	0	1	1	0	?	1	0	0	1	0	0	0	?	?	?	?	0	0	1	1
Huia gracilis	?	1	0	1	0	1	0	?	?	?	?	?	?	?	1	0	0	0	?	?	?	?	0	?	?	1
Konioria andrychoviensis	0	1	?	?	1	1	0	1	1	0	?	?	?	?	?	0	1	0	1	1	0	0	0	?	?	1
Margophyton goldschmidtii	?	1	0	?	0	1	0	?	?	?	?	?	?	?	?	0	1	0	0	1	0	0	0	0	1	1
Nothia aphylla	?	0	?	?	1	0	0	0	0	?	?	1	1	0	1	0	0	0	?	?	?	?	1	0	1	1
Sawdonia ornata	?	1	?	?	0	0	1	1	1	?	?	1	0	0	1	1	1	0	0	0	1	0	0	0	1	?
Serrulacaulis furcatus	?	1	0	1	?	?	?	?	?	?	?	?	?	?	1	0	0	1	0	1	0	0	0	?	?	0
Stolbergia spiralis	0	1	0	1	1	0	0	1	?	?	?	1	0	0	?	0	0	0	?	?	?	?	0	?	?	?
Thrinkophyton formosum	?	1	1	1	0	1	0	?	?	?	?	?	?	?	?	1	0	0	?	?	?	?	0	0	1	1
Trichopherophyton teuchansii	0	1	?	1	1	0	0	1	0	?	?	0	0	1	?	1	0	0	?	?	?	?	0	?	?	?
Ventarura lyonii	?	1	0	1	1	0	0	1	0	?	1	?	?	?	?	0	0	0	?	?	?	?	0	1	0	1
Zosterophyllum fertile	?	1	?	1	1	0	0	1	1	0	?	?	?	?	?	0	0	0	?	?	?	?	0	1	0	1
Zosterophyllum llanoveranum	?	1	?	?	1	0	0	1	1	1	?	?	?	?	?	0	0	0	?	?	?	?	0	?	?	?

Supplemental Material for: Megan Nibbelink, Alexandru M.F. Tomescu. 2022. "Exploring Zosterophyll Relationships within a More Broadly Sampled Character Space: A Focus on Anatomy." International Journal of Plant Sciences 183(6). DOI: 10.1086/720384.

Appendix 7. Phenetic matrix for UPGMA analyses (continued); for the NMDS analyses, "?" is converted to "0".

Characters	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Renalia hueberi	0	0	0	0	0	0	0	?	?	?	?	?	?	?	?	?	?	0	1	0	1	1	1	1
Crenaticaulis verruculosus	?	0	0	1	1	0	1	1	0	0	?	0	1	1	0	1	0	0	1	0	1	0	1	0
Deheubarthia splendens	0	0	0	1	1	0	1	1	0	0	?	0	1	1	0	1	0	0	1	0	1	0	1	?
Discalis longistipa	?	?	1	0	1	0	1	1	0	1	0	1	0	0	0	0	1	0	1	0	1	1	1	1
Sawdonia deblondii	?	0	1	1	1	0	1	0	1	0	?	?	?	?	1	0	0	0	1	0	1	1	1	1
Euthursophyton hamperbachense	0	0	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Gosslingia breconensis	1	0	0	1	1	0	1	1	1	0	?	?	?	?	1	0	0	1	0	0	1	0	1	1
Huia gracilis	0	1	1	1	0	0	1	1	0	1	0	1	0	0	0	0	1	0	0	1	1	1	0	0
Konioria andrychoviensis	1	0	0	0	1	1	0	0	1	?	?	?	?	?	?	?	?	?	?	?	1	0	1	1
Margophyton goldschmidtii	0	1	0	1	0	1	0	0	1	?	?	?	?	?	?	?	?	1	0	0	1	0	?	?
Nothia aphylla	0	0	0	0	0	0	1	1	0	1	0	1	0	0	?	?	?	0	0	1	1	1	1	0
Sawdonia ornata	?	1	1	0	1	0	1	1	0	1	1	0	0	1	0	1	0	0	0	1	1	0	1	0
Serrulacaulis furcatus	1	0	?	0	1	0	1	0	1	0	?	1	0	0	0	1	0	1	0	0	1	0	1	1
Stolbergia spiralis	?	0	0	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Thrinkophyton formosum	0	0	0	1	1	0	1	1	0	0	?	0	0	0	0	1	0	0	1	0	1	0	1	1
Trichopherophyton teuchansii	?	?	?	0	1	?	?	?	?	?	?	?	?	?	?	?	?	0	1	0	0	?	1	1
Ventarura lyonii	0	?	?	0	0	0	1	?	?	1	1	?	?	?	?	?	?	1	0	0	0	?	1	1
Zosterophyllum fertile	0	0	0	0	1	0	1	1	0	1	1	1	0	0	0	1	1	0	1	0	1	1	0	1
Zosterophyllum llanoveranum	?	?	?	?	?	0	1	1	1	1	1	?	?	?	1	1	0	0	1	0	1	1	1	1

Appendix 7. Phenetic matrix for UPGMA analyses (continued); for the NMDS analyses, "?" is converted to "0".

Characters	51	52	53	54	55	56	57
Renalia hueberi	1	0	0	1	0	0	0
Crenaticaulis verruculosus	0	1	0	?	0	0	0
Deheubarthia splendens	1	0	0	0	0	0	0
Discalis longistipa	1	0	0	1	1	0	1
Sawdonia deblondii	0	1	0	0	1	0	1
Euthursophyton hamperbachense	?	?	?	?	?	?	?
Gosslingia breconensis	1	0	0	1	0	0	0
Huia gracilis	1	0	1	0	0	0	0
Konioria andrychoviensis	1	0	0	0	1	1	0
Margophyton goldschmidtii	1	0	?	?	0	0	0
Nothia aphylla	1	0	0	0	0	0	0
Sawdonia ornata	0	1	0	0	0	0	1
Serrulacaulis furcatus	1	0	0	1	0	0	0
Stolbergia spiralis	?	?	?	?	?	?	?
Thrinkophyton formosum	1	0	0	1	0	0	0
Trichopherophyton teuchansii	0	1	0	0	1	1	0
Ventarura lyonii	1	0	0	1	0	0	0
Zosterophyllum fertile	?	?	0	1	0	0	0
Zosterophyllum llanoveranum	1	0	0	1	0	0	0